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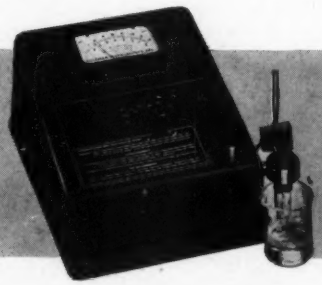

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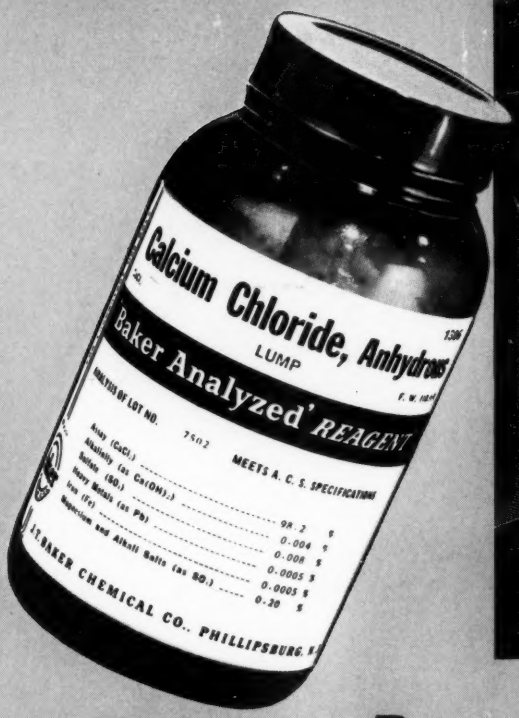

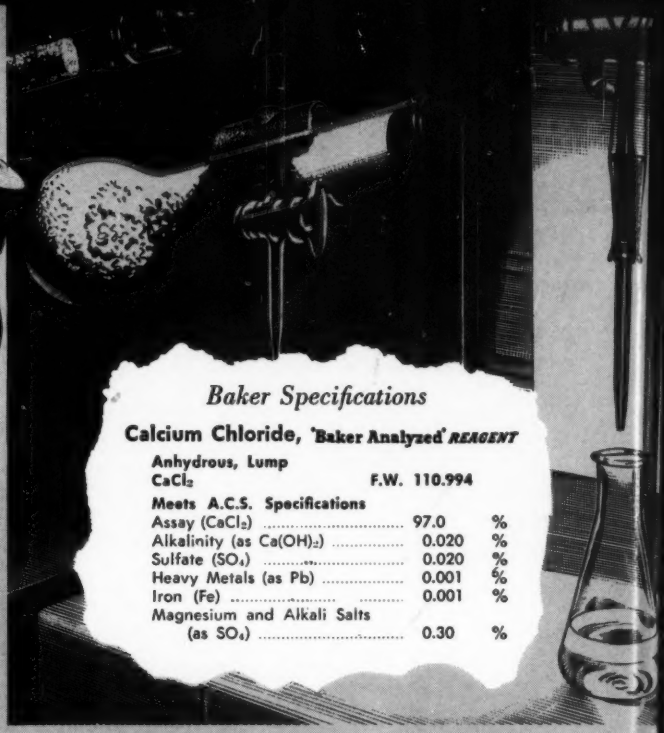

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VOLUME 31

February 1954

NUMBER 2

JOURNAL OF CHEMICAL EDUCATION

Published by the
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Subscription Price: Domestic $3.50 per year; Countries in Pan-American Union $3.50 per year; Canada $4.00; other countries $4.50. Issued monthly. Single copies of issues in current year, 50¢ each; all other single copies, one dollar. Foreign remittances must be accompanied by International Money Order.

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The JOURNAL OF CHEMICAL EDUCATION is the official organ of the Divisions of Chemical Education and History of Chemistry and incorporates the Report of the New England Association of Chemistry Teachers, and the Proceedings of the Pacific Southwest Association of Chemistry Teachers. It is indexed in the Education Index, Industrial Arts Index, and, in part, in the Quarterly Cumulative Index Medicus.

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Editor's Outlook

DAVID STARR JORDAN used to have a favorite saying: "There is one thing of which we can be sure: that none of our ancestors ever died in infancy." This is, of course, a biologist's facetious way of saying that a species which does not reproduce itself is doomed to extinction. It is also true of professions, in particular—chemistry.

Certainly neither David Starr Jordan nor I is being very profound in calling attention to this; it is very obvious. Futhermore, we—in chemistry—have long recognized the fact.

Out here on the Pacific Coast we have been observing for several years decreasing catches of sardines. There has been a great "to-do" over this and a big investigation has been under way to find out what the trouble is. Where are the sardines? Have we been catching too many and chopping them up into fertilizer? Have they gone off to some other part of the ocean? There is a strong feeling that the important thing is to find out what is happening to the very young ones, the "small fry."

Through the country something of the same sort seems to be happening to chemists. Every year the "catch" is smaller. Industry, of course, says that we must not merely have *more* chemists but more *good* chemists. After all, if a fish doesn't measure up to the legal limit he is thrown back into the pool again—perhaps to be gobbled up by his bigger brothers.

But with chemists, too, perhaps the important thing is to find out what is happening to the very young ones. Actually, our laws seem to protect young fish more carefully than young chemists.

But when we go into the process by which young chemists are produced (or "spawned") our easy biological analogy breaks down. So let's leave it. Here is where the secondary-school teacher comes into the picture, for most of the young chemists are the result of his activity.

We recognize this fact but we don't give it proper weight. To be sure, there are some reasons why the chemical profession is frustrated in its feeble efforts to do something about (and for) the secondary-school chemistry teacher. The organization and administration of the typical high school—and the whole elementary and secondary educational system, for that matter—are such as to repel any intrusion. But how many of our profession really give a tinker's dither about that educational system, when you come right down to it? Maybe the way for us to accomplish eventual results is to become interested in it from some motive other than our own professional vested interest.

But how about the high-school teacher? We think of him (if at all) as a feeble lost voice in the wilderness, perhaps trying to find his way to true salvation but surrounded by iniquitous influences which prevent him from shouting the gospel that we think he should be spreading. But we don't even give him the support and encouragement we give our missionaries.

Our real, serious shortage is in teachers. It takes only a short time to get a new student into the chemistry class; it takes years to prepare the teacher. And the new supply is becoming smaller and smaller.

Indeed, there is no level on the educational ladder at which the supply of teachers is really adequate, but most acute of all is the situation at the lowest level, which for us in chemistry is in the secondary school. We must be prepared for the possibility of chemistry being eliminated as a separate subject in the high school. While that time is certainly not imminent, its coming will be hastened by those forces which are tending to bring about the extinction of the secondary-school chemistry teacher as a separate species. Among these forces are discouragement, frustration, and economic and social pressure.

Why should a bright young chemist *want* to be a secondary-school teacher? I am rather afraid that the brighter he is the more likely he will be to go elsewhere. First of all, there is little money in it; most bright young chemists will look no further.

But there is more. The kind of young men (or women) we want for teachers, and who are likely to be most successful in such a career, are those who *will* look beyond the dollar sign to find other compensations. Nevertheless, many a really good teacher has been lost to the profession because of "economic pressure." This is a loss which we must at least try to prevent, but there are very difficult problems here which will not be easily solved. Comparison with the wage scale of unskilled but highly organized labor is agitating but fruitless.

But we can, if we will, have some control over the intangible factors. First of all, we can make the situation of the secondary-school teacher more respectable, professionally and socially. Let us acknowledge the *important* part he plays in the profession, as well as the fact that in many ways he is uniquely adapted to his job—that he can probably do it better than the college professor could, or the industrial research executive. We can make him proud of his position and encourage him to stand up in his place among the other members of our profession. These things we can give him immediately, while the larger pay check, which he deserves, may be longer in coming.

THE USE OF A RADIO-FREQUENCY OSCILLATOR IN STUDENT ANALYSIS[1]

JAMES L. HALL, JOHN A. GIBSON, JR., HAROLD O. PHILLIPS, and FRANK E. CRITCHFIELD
West Virginia University, Morgantown, West Virginia

DURING the last few years much interest has arisen in the use of radio-frequency (abbreviated r-f.) oscillators and bridges as an aid to the determination of end points for volumetric analyses and for the determination of the composition of solution and liquid mixtures. The most attractive feature of methods based on such oscillators

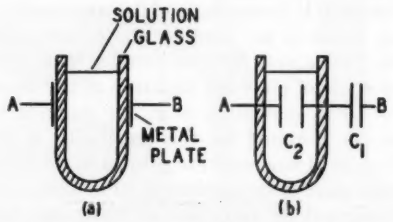

Figure 1. (*a*) **High-frequency Cell.** (*b*) **Equivalent Circuit of High-frequency Cell**

is their use of reaction vessels or cells which are made of glass or some other insulating material without electrodes in direct contact with the solution. Recently it has been shown that the radio-frequency response of such circuits is a simple function of the conductance and dielectric constant of the solution within the vessel (*1*, *2*, *3*).

The method may be introduced into the student laboratory as an additional and sometimes advantageous conductimetric and dielectric constant method. This article sets forth the principles of the method, describes an easily constructed apparatus, and illustrates experimental procedures which may be used for instructional purposes.

PRINCIPLES

The present discussion will be limited chiefly to studies made in glass cells with metal plates or electrodes outside the glass. Studies thus far described have been of two types: (*a*) studies in which the oscillator or r-f. bridge response is primarily dependent upon the dielectric constant or dielectric constant change of a non-conducting solvent mixture, and (*b*) studies in which the oscillator or r-f. bridge response is primarily dependent upon the conductance or changes in conductance of a solution in which the composition of the solvent is constant.

If a non-conducting liquid is placed in a glass vessel (cell) with metal plates attached to the outside of the glass, the r-f. electrical behavior of the system will be similar to one in which the metal plates are in direct contact with the liquid but with a series capacitor placed in one of the leads of the cell. This situation is represented diagrammatically in Figure 1. Here C_2 represents the capacitance which would be obtained if the metal plates were in direct contact with the solution and hence is a function of the dielectric constant of the solvent. The capacitance C_1 takes the place of the capacitance resulting from the insulating walls of the vessel. The net capacitance of two capacitors in series is given by

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} \quad \text{or} \quad C_T = \frac{C_1 C_2}{C_1 + C_2} \tag{1}$$

If the dielectric constant of a non-conducting liquid in the cell is varied from unity toward infinity, the capacitance of C_2 will vary from a fixed value, determined by the geometry of the cell, to infinity at infinite dielectric constant. Thus the value of the net capacitance across AB (Figure 1) will approach the value of C_1 as a limit. This relation is shown in Figure 2,

[1] Presented before the Division of Chemical Education at the 124th Meeting of the American Chemical Society, Chicago, September, 1953.

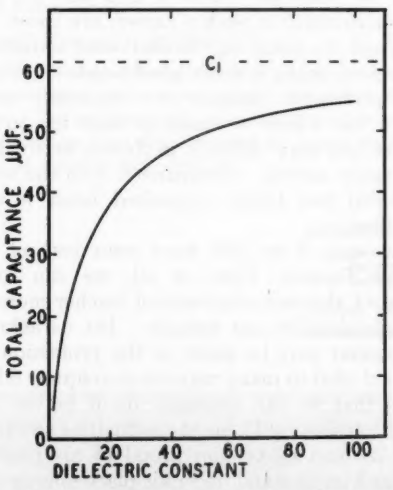

Figure 2. Total Capacitance Calculated for a Cell for Which C_1 is 61.5 μμf. and C_2 is 4.8 μμf. for Air in the Cell

using values for the cell described by Hall and Gibson (*4*), where C_1 is 61.5 micromicrofarads (abbreviated $\mu\mu$f.) and C_2 is 4.8 $\mu\mu$f. with air in the cell.

For any given cell used with an r-f. capacitance bridge, or with an oscillator having the cell in parallel with the tuning capacitor, a calibration curve of the type of Figure 2 may be constructed. Liquids of known dielectric constant are used to relate dielectric constant to the bridge reading or oscillator capacitor dial reading. A method similar to the one suggested here was first described by Fischer (*5*) except that in his method the glass container was placed in the center of the inductance coil of the oscillator.

The advantages of this indirect method for the determination of dielectric constant are that there can be no interaction of solution and the metal electrodes, that polarization effects are totally eliminated, and that dielectric constants over the range unity to 80 may be obtained with a simple oscillator. The disadvantages are that the calibration curve is not linear and that the series capacitance effect of the cell wall reduces the absolute sensitivity, although this may be compensated for by using greater electrode areas. To secure greater sensitivity at high dielectric constants it is necessary to increase the relative value of C_1 by using a thinner cell wall or cell wall material of higher dielectric constant, or by alteration of the geometry of the cell and electrodes.

In case the solution within the cell has appreciable conductance, the approximate equivalent circuit may be represented by placing a resistance in parallel with C_2 (Figure 1*b*) as is shown in Figure 3. Detailed discussions and explanations of the electrical behavior of this circuit in relation to cells for analysis at high frequencies have been given elsewhere (*1*, *2*, *3*). It has been shown that the over-all conductance and capacitance are, for dilute ionic solutions, unique functions of the dielectric constant of the solvent and of the ordinary low-frequency conductance of the solution. An equation for the r-f. conductance, G, which would be measured across the terminals AB (Figure 3) has been given by Reilley and McCurdy (*3*) as:

$$G = \frac{k\omega^2 C_1^2}{k^2 + \omega^2(C_2 + C_1)^2} \qquad (2)$$

where k is the actual low-frequency conductance of the solution, ω is 2π times the frequency, and C_1 and C_2 are constant for any given cell and solvent. A plot of experimental data illustrating this equation is shown in curve (*a*) of Figure 4, for the cell described by Hall and Gibson (*4*) at 5.0 megacycles. For convenience the abscissa is plotted as K_0, the specific conductance, which is proportional to k, the total conductance of equation (2).

The equation for the equivalent r-f. capacitance across the terminals AB (Figure 3) has also been derived by Reilley and McCurdy (*3*) and this is given by

$$C_T = \frac{C_1k^2 + \omega^2C_1C_2^2 + \omega^2C_2C_1^2}{k^2 + \omega^2(C_1 + C_2)^2} \qquad (3)$$

A plot of experimental data illustrating this equation is shown as curve (*b*) of Figure 4. It is seen that for any given solvent and cell, both the r-f. conductance and capacitance of the cell containing the conducting solution are unique functions of the solution conductance within the cell. For end-point determinations involving solutions of ionic substances the factor responsible

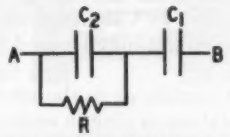

Figure 3. Equivalent Circuit for High-frequency Cell Containing Conducting Solution

for the radio-frequency instrument response is the change in the ordinary conductance of the solution. This is true whether the r-f. quantity measured is capacitance change or conductance change or some oscillator parameter dependent upon one or both of these.

The relation between the forms of the ordinary conductance titration curves and the high-frequency titration curves may be shown by methods described by

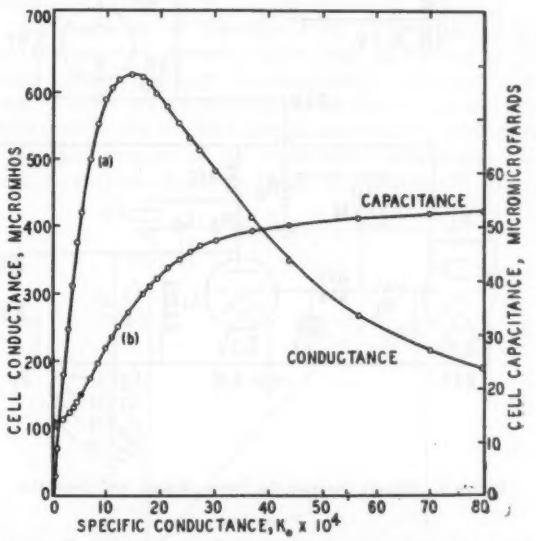

Figure 4. (*a*) Cell Conductance and (*b*) Cell Capacitance as a Function of Solution Conductance at 5.0 Megacycles

Hall (*1*), by Blaedel, Malmstadt, Petitjean, and Anderson (*2*) or by transfer plots first used by Reilley and McCurdy (*3*). The construction of a transfer plot will be described later.

APPARATUS

The laboratory experiment described here is based upon a modification of the apparatus described by Hall (*6*), although a similar experiment could be devised for other types of apparatus which have been described or which are available commercially. The

circuit of the modified apparatus is shown in Figure 5, and Figures 6 and 7 show photographs of the apparatus and complete titration assembly. The modified apparatus has advantages over ones previously described. All parts listed are readily available from radio supply houses. A voltage-regulated power supply is included on the same chassis. A separate 6E5 tube is used as oscillation indicator only. The magnitude of the vacuum-tube voltmeter (VTVM) responses is considerably increased and the circuit may be used to 10 megacycles or higher.

In the present circuit, as in the previous ones, both the coil and crystal are in plug-in sockets. The present apparatus performs equally well at 2.0 and 5.0 megacycles and almost as well at 10.7 megacycles. The values of R_1, R_2, and R_3 may need to be adjusted slightly to secure total closing of the eye at the frequency chosen, and to secure the desired range of voltmeter response. The number of turns on the oscillator coil should be adjusted so that there is no oscillation with the cell disconnected and the variable capacitor plates totally meshed, but oscillation is started by a few degrees of opening of the tuning capacitor plates. Polystyrene sheet or other insulating material is placed

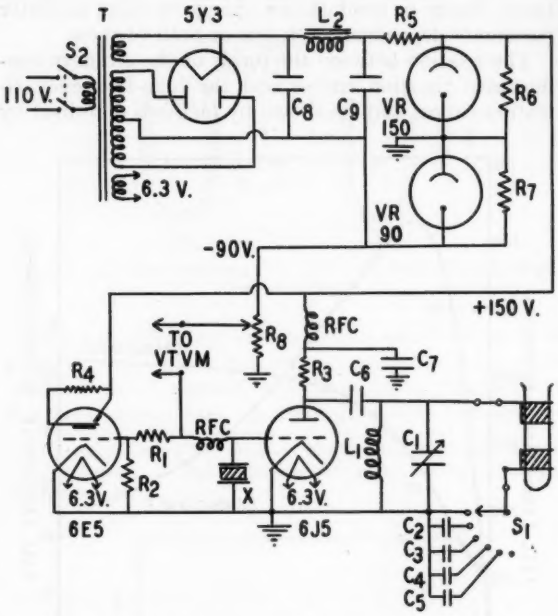

Figure 5. Circuit Diagram for Power Supply and Oscillator

PARTS LIST

5Y3	
VR 150	
VR 90	
6E5	
6J5	
R_1	15,000 ohms, 1 watt
R_2	4700 ohms, 1 watt
R_3	2000 ohms, 1 watt
R_4	1 megohm, 1/4 watt
R_5	5000 ohms, 10 watt
R_6	15,000 ohms, 20 watt
R_7	100,000 ohms, 1 watt
R_8	10,000 ohms, ww. potentiometer
C_1	100 μμf., variable straight-line capacity
C_2	30 μμf., mica
C_3	15 μμf., mica
C_4	5 μμf., mica
C_5	2 μμf., mica
C_6,C_7	0.002 μf., 600 volt, paper
C_8	10 μf., 450 v., electrolytic
C_9	30 μf., 450 v., electrolytic
S_1	Six-position rotary switch
S_2	DPST toggle switch
X	Crystal in plug-in socket, 2.0, 5.0 or 10.7 megacycles
L_1	Coil on 1 1/4-in. Polystyrene form, No. 24 dcc. wire, 55 turns for 2.0 megacycles, 15 turns for 5 megacycles, 7 turns for 10.7 megacycles
L_2	10.5 henry, 225-ohm choke (Stancor C-1001)
RFC	2.5 millihenry r-f. choke
T	Power transformer (Stancor PC-8407 or PM-8407) National N-PWO dial drive mechanism

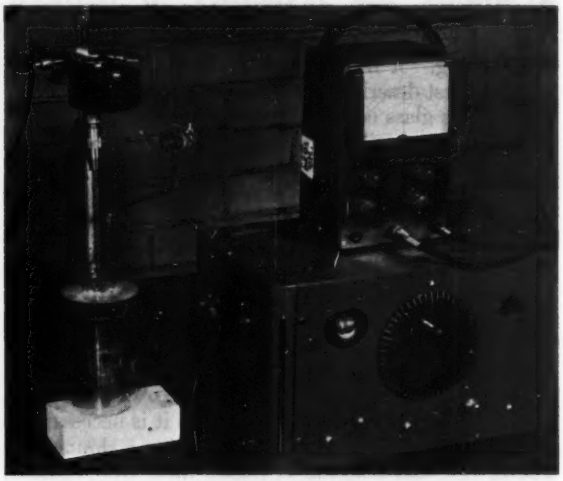

Figure 6. Apparatus and Titration Assembly

in the openings at the sides of the cabinet. The phone-tip jacks for the vacuum-tube voltmeter are mounted in the right insulating panel and the series condenser switch and cell jacks are mounted in the left panel. Any vacuum-tube voltmeter having d.-c. ranges to 50 volts may be used. The high-frequency cells used in the work reported here were all similar to the one described by Hall and Gibson (*4*), consisting of copper bands around the outside of a glass tube. During titration an ordinary motor-driven glass stirrer was in continuous operation in the cell.

OPERATION AND RESULTS

The apparatus just described may be used in the analytical laboratory in four ways: (*a*) for direct dielectric constant determinations, (*b*) for indirect dielectric constant determinations in insulated cells, (*c*) for conductimetric titrations in insulated cells, and (*d*) for conductimetric titrations with electrodes in contact with the solution. Experiments and results for each will be described. The apparatus, as described above, has been used in our laboratory with crystals and coils for 2.0, 5.0, and 10.7 megacycles. Unless otherwise specified, the results reported here are for 5.0 megacycles.

DIRECT DIELECTRIC CONSTANT DETERMINATION

For direct dielectric constant determination, the procedure is as described by Bender (*7*). A cell of the type described by Bender is plugged into the apparatus, and the series capacitor switch is set in the first (direct) position. The vacuum-tube voltmeter is not needed. The only data required are the dial readings at which

the eye snaps shut as the tuning capacitor is opened from the region of no oscillation. The procedure, results, and range of usefulness are as described by Bender and will not be discussed further. If a straight-line capacity condenser (semicircular plates) is used, the dial reading increments should be nearly enough proportional to capacitance increments to yield reasonably accurate dielectric constant data without further calibration. The dial may be calibrated in exact or relative terms as described by Smyth (*8*).

INDIRECT DIELECTRIC CONSTANT DETERMINATION

For indirect dielectric constant determination, a high-frequency (insulated) cell is plugged into the apparatus and the capacitor switch is set in the direct position. The operation and results are similar to those described by Fischer (*5*) except we believe that improvement is made by use of the capacitor-type cell. To determine dielectric constant by this method, liquids of known dielectric constant are used for calibration. The table lists the liquids used for calibration of

Liquid	*Measured dielectric constant*	*Capacitance increment dial divisions*
t-Butyl alcohol	12.40	8.8
t-Butyl alcohol-water mixture no. 1	17.10	12.0
t-Butyl alcohol-water mixture no. 2	26.42	18.0
t-Butyl alcohol-water mixture no. 3	38.1	24.5
t-Butyl alcohol-water mixture no. 4	55.4	33.3
t-Butyl alcohol-water mixture no. 5	69.7	40.5
Water	78.5	44 0
Methyl alcohol	32.9	21.2
Methyl alcohol-water mixture no. 1	50.5	31.0
Methyl alcohol-water mixture no. 2	68.5	39.2
Nitroethane	28.6	19 8
Chloroform	4.92	4.0
Isopropyl bromide	9.72	7.3
Benzene	2.33	1.2
Aniline	7.32	5.3
Carbon tetrachloride	2.27	1.1

the instrument, their dielectric constants, and their respective capacitance increments on the apparatus at 5.0 megacycles. The dielectric constants of the mixtures were determined experimentally with the apparatus described by Critchfield, Gibson, and Hall (*9*). All data are at 25°C.

All dial readings were taken for the value at which the eye snapped shut with decreasing capacitance. The dial reading differences were plotted as a function of dielectric constant as shown in Figure 8. For any unknown liquid, the dial increment is determined and the dielectric constant is read from the curve. For laboratory unknowns we have used methanol-water mixtures with dielectric constants taken from the results of Albright and Gosting (*10*), and dioxane-water mixtures with constants from the data of Critchfield,

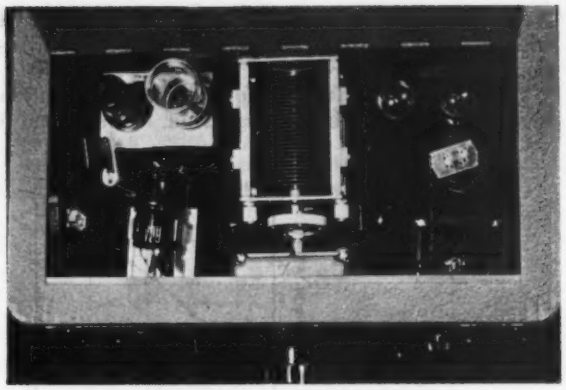

Figure 7. Apparatus, Top View

Gibson, and Hall (*9*). A calibration curve and several unknowns should be completed in one 3-hour laboratory period.

TITRATIONS IN HIGH-FREQUENCY INSULATED CELLS

The procedure was as described by Hall (*6*), with the addition of a transfer plot, as described by Reilley and McCurdy (*3*).

Determination of Transfer Plot. The form of the radio-frequency titration curve may be related to the form of the ordinary low-frequency conductance titration curve by considering the relation of the cell conductance to the conductance of the solution within the cell. The results of an experiment illustrating this relationship are shown in Figure 9. Curve (*B*) shows,

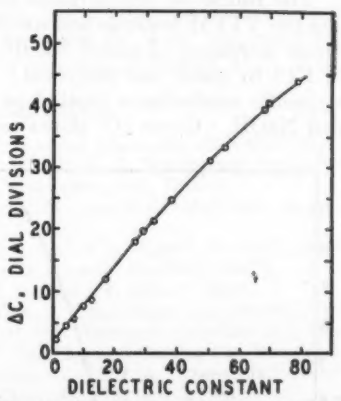

Figure 8. Calibration Curve for Determination of Dielectric Constant in Insulated Cell with 5.0 Megacycle Crystal Oscillator

for the 5.0 megacycle crystal oscillator, the relation of the specific conductance of the solution in the cell to the vacuum-tube voltmeter readings. This curve was obtained by placing 80 ml. of distilled water in the cell and adding 0.1 *N* KCl in small increments. After each addition the oscillator was adjusted for maximum VTVM response, and the VTVM reading was recorded. The specific conductance of the solution was obtained at each point by use of an Industrial Instruments Type

RC Conductivity Bridge and a dip conductivity cell with platinized platinum electrodes, placed in the titration vessel for each reading.

The titration of HCl solution with NaOH solution was then performed by placing 72 ml. of water and 8

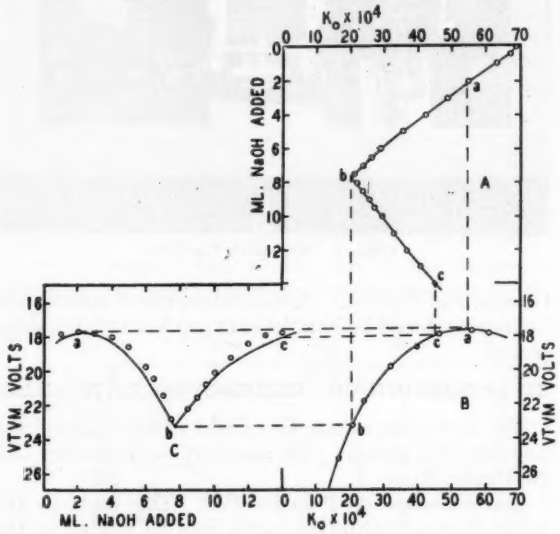

Figure 9. Correlation of High-frequency Conductance Titration Curve with Ordinary 1000-Cycle Conductivity Titration Curve

A. Ordinary conductivity titration. *B.* Transfer plot. *C.* High-frequency titration.

ml. of 0.02 *N* HCl in the titration cell and adding 0.02 *N* NaOH. The course of this titration was followed by observing the VTVM readings and specific conductance after each increment of added NaOH, as for the addition of KCl to water just described. Curve (*A*) shows the specific conductance plotted as a function of the added NaOH. Curve (*C*) shows as circles the

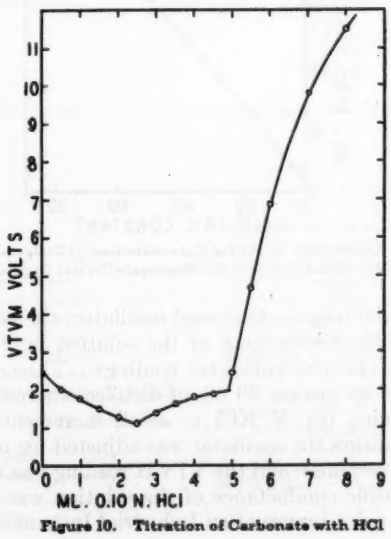

Figure 10. Titration of Carbonate with HCl

experimental VTVM readings as a function of the added NaOH. The solid line of curve (*C*) shows the results of projecting curve (*A*) by means of the transfer plot (*B*). The dashed lines indicate the method of making the projection. A similar transfer plot and correlation could be made by using the capacitance response of the instrument as a function of the added electrolyte concentration.

VOLUMETRIC ANALYSES

An inspection of Figure 4 shows that the sensitivity, defined as the rate of change of the instrument response with change of solution conductance, varies with concentration (or conductance). The sensitivity of the

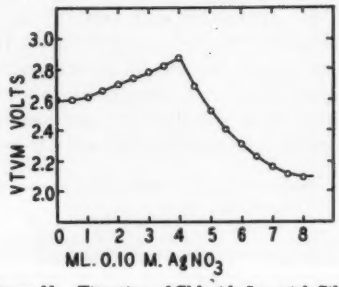

Figure 11. Titration of Chloride Ion with Silver Ion

conductance response is greatest at low concentrations, is zero at the maximum of curve (*a*) of Figure 4, and is good in a higher range of concentration. The sensitivity of the capacitance response is greatest in the region in which the sensitivity of the conductance response is zero. A practical limit to the usefulness of

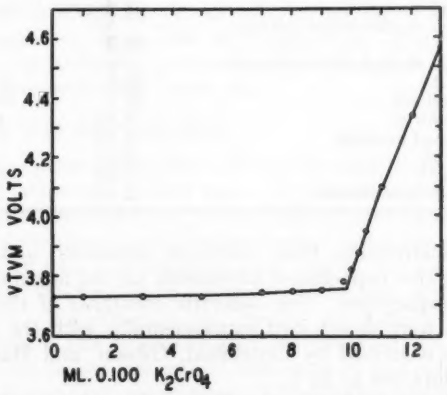

Figure 12. Titration of Barium Ion with Chromate Ion

the instrument is determined by the total conductance of the solution to be studied. For titrations in aqueous solutions this limit is reached with solutions having a total conductance equal to that of about 0.2 *N* KCl. The VTMC response of the oscillator described here is not linear with the cell conductance component, tending to be less sensitive at lower VTMC readings, corresponding to greater loading of the oscillator circuit. For

solutions for which the conductance is in the vicinity of the maximum of curve (*a*) of Figure 4, improvement in the titration curve may be obtained by using one of the series condensers, C_2 to C_5 of the oscillator circuit. A trial titration may be necessary to determine the best setting of the selector switch for any particular solution.

Titration of Carbonate with HCl. Figure 10 shows the VTVM response for titration of 5 ml. of 0.10 *N* Na_2CO_3 plus 75 ml. of water in the titration cell with 0.10 *N* HCl. The frequency was 5.0 megacycles. The 30 $\mu\mu$f. series condenser was used. The voltmeter was arbitrarily set at the beginning of the titration by use of R_8. Both the carbonate and bicarbonate end points are clearly shown.

Titration of Chloride Ion with Silver Ion. Figure 11 shows the VTVM response for titration of 4 ml. of 0.10 *M* KCl plus 76 ml. of water in the titration cell with 0.10 *M* $AgNO_3$ solution. The frequency was 10.7 megacycles and the 5 $\mu\mu$f. series condenser was used. The voltmeter was arbitrarily set at the beginning of the titration.

Titration of Barium Ion with Chromate Ion. Figure 12 shows the VTVM response for titration of 0.262 gram of $Ba(NO_3)_2$, dissolved in 80 ml. of water in the titration cell, with 0.1003 *M* K_2CrO_4 solution. One drop of dilute ammonium hydroxide was added to give a basic solution. This titration was performed at 2.0 megacycles using the apparatus previously described (*6*). The end point obtained from the plot of the data is 9.8 ml. The difference from the theoretical end point of 10.0 ml. is attributed to impurity in the $Ba(NO_3)_2$ used.

TITRATION WITH ELECTRODES IN CONTACT WITH SOLUTION

For acid-base neutralizations in non-aqueous systems the conductance of the solutions and changes of conductance may be of the order of micromhos. Ordinary conductance bridges are insensitive to conductances or changes of conductance of this magnitude. For high-frequency titrations as just described, for such slightly conducting solutions, the series capacitor effect of the glass cell reduces the response so that under these conditions the high-frequency oscillator is also insensitive to such solutions. Many such solutions have a conductance such that the high-frequency oscillator may be used in conjunction with a cell which has electrodes in direct contact with the solution.

Titration of Diethylamine with Perchloric Acid in Glacial Acetic Acid. A solution of 5 ml. of 0.0972 *M* diethylamine in glacial acetic acid was mixed with 75 ml. of glacial acetic acid and placed in the titration vessel. A dip type conductivity cell with bright platinum electrodes was placed in the solution and was connected directly to the 5.0 megacycle oscillator without the use of a series capacitor. This solution was titrated with an 0.1008 *M* perchloric acid solution in glacial acetic acid with the results shown in Figure 13. The

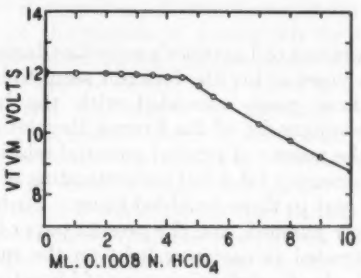

Figure 13. Titration of Diethylamine in Glacial Acetic Acid with Perchloric Acid in Glacial Acetic Acid. Bright Platinum Electrodes in the Solution

actual voltmeter reading at the start of this titration was 43 volts, indicating very slight loading of the oscillator. The VTVM was arbitrarily adjusted to 12 volts at the start of the titration to take advantage of a lower range on the voltmeter. For this titration the calculated end point was 4.6 ml. and the observed end point was the same, within the precision of reading the graph.

ACKNOWLEDGMENT

This work was a joint undertaking of the Department of Chemistry of West Virginia University and the Office of Ordnance Research, U. S. Army.

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ANTOINE LAURENT LAVOISIER AND THE FRENCH REVOLUTION

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A FULL account of Lavoisier's activities during the last five or six years of his life does not seem to have been given. These years coincided with the beginnings and the development of the French Revolution, and a study of the masses of printed material relative to this epoch is necessary for a full understanding of the great chemist's part in those troubled times. Such a task is being slowly pursued, and the present paper is the first of two intended to cast new light on the subject and form the basis of a definitive story of his activities during this exciting period.

LES ACTES DES APOTRES

Without exception, biographical accounts of these years of Lavoisier's life are based upon the work by Grimaux[1] and give the impression that Lavoisier was the victim of scurrilous attacks by partisans of the left,[2] and that these, together with his well-known connections with the *ancien régime*, were responsible for his condemnation and execution. The facts lead to the conclusion that his undoing was connected solely with his membership of the hated Ferme-générale and had nothing to do with any particular virtues or vices which he may have had.

Lavoisier's execution at the hands of the left was ironical, for he was extremely liberal in his political views, and with his genius for planning and organization, he would have been able to make great contributions to the cause of the young republic. A recent discovery has brought to light the fact that, far from being an idol of the parties of the right, Lavoisier was actually the target for a spiteful attack by the editors of the *Actes des Apôtres* [9th *version*, No. 256, pp. 10–2, 1791].

The *Actes des Apôtres* was a violently antirevolutionary periodical which appeared on alternate days. Each issue, which was octavo in size, varied from 8 to 64 pages, and 30 tissues made up a *version*, of which ten were published between November 2, 1789, and the *Saint-André* (June 20) of 1791. For each *version* an engraved frontispiece, title-page, and introduction were printed—the latter usually explaining the allegorical meaning of the frontispiece. A detailed account of the contents of the periodical is given by Martin and Walter.[3] Some of the circumstances attendant on its publication are related by Challamel,[4] who records that the editors of the *Actes des Apôtres* used to meet at the home of the Marquise de Chambonas and draft the periodical over meals taken in private rooms in the restaurant of Beauvilliers in the Palais Royal. The final manuscript was frequently drafted on the back of one of Beauvilliers' menus and then passed next door to the publisher Gattey, who operated a bookshop. In addition, the editors attended regular weekly dinners at Mafs' restaurant, also in the Palais Royal. Both these restaurants were notorious hotbeds of counter-revolutionary activities, and Gattey published a number of reactionary pamphlets; his actions drew down on his store a violent attack by the mob and closure by the authorities. He was finally guillotined for his anti-revolutionary activities; it is related[5] that, on hearing him sentenced, his sister committed suicide by repeatedly crying "Vive le Roi" in open court and thus getting herself sentenced to death forthwith.

The occasion which caused the sarcastic attack on Lavoisier has been fully recorded by Grimaux[6] and occurred when he was offered a post as commissioner of the Trésorerie nationale, and when he refused to accept any salary for the duties connected with it. Apparently in order to preclude any misconceptions of his actions, he published in the *Moniteur* of April 9, 1791, an open letter to the minister of finance, Delessart, in which he explained his motivations for this refusal. This letter was also the subject of an incident between Brissot, leader of the Girondins, and Lavoisier (*vide infra*).

As this seems to be the first attack on the great scientist to have come from the right and to be recorded, it is thought worth giving it in full.

[1] GRIMAUX, EDOUARD, "Lavoisier, 1743–1794, d'après sa correspondance, ses manuscripts, ses papiers de famille et d'autres documents inédits," Paris, 1888.

[2] Especially by Marat who, early in his career, had scientific ambitions, and who had claimed that his worthless book, "Recherches physiques sur le feu," Paris, 1780, was published with the Académie's approval. Lavoisier gave the lie to this claim, and Marat hated him ever afterwards, and denunciated him in his periodical, *Ami du peuple*, in the most violent terms. See GRIMAUX, E., *op. cit.*, p. 206.

[3] MARTIN AND WALTER, "Catalogue de l'histoire de la révolution française," Paris, 1943, Vol. 5, pp. 36–47.

[4] CHALLAMEL, AUGUSTIN, "Les clubs contre-révolutionnaires," Paris, 1895, p. 7.

[5] LENÔTRE, G., "Le Tribunal révolutionnaire," Paris, 1908, p. 218.

[6] GRIMAUX, E., *op. cit.*, pp. 209–10.

SUR LA LETTRE
DE MONSIEUR LAVOISIER

Insérée dans le Moniteur du samedi 9 Avril

Généreux Lavoisier, ta lettre pathétique
M'a fait, je l'avouerai, presque verser des pleurs:
Tu viens de conquérir à la fois tous les coeurs,
En nous développant ta conduite héroïque.
Quel exemple étonnant de modération!
Se contenter d'avoir cent mille écus de rente
Qu'on a gagné, Dieu sait! puis à sa nation
Donner son temps pour rien,* cet exemple me tente.
Ah! que ne puis-je, hélas! pouvoir en faire autant?
Entre nous, je vois bien que Neckre [*sic*] est ton modèle,
Comme lui tu ne veux aucun appointement;
Mais aussi, comme lui, tu sais parfaitement
Combien tu puiseras dans la caisse nouvelle.
Notre maître adoré ne pouvait mieux qu'en toi,
Au gré de ses sujets placer sa confiance;
Ils sont tous effacés les malheurs de la France,
Quand tu daignes céder aux instances du roi;
Et le ciel nous permet encore l'espérance.
Ton égal en vertus, le digne Condorcet,
Depuis qu'il n'est plus noble a lorgné sa fortune:
Blasé d'honneurs, pour lui la gloire est trop commune;
C'est une illusion, il lui faut de l'effet.
Il est beau d'être inscrit au temple de mémoire;
Mais celui de Plutus a son mérite aussi:
L'académicien pour reposer sa gloire,
En gros financier se transforme aujourd'hui.
Vous voilà donc tous deux colonnes de la France!
Vous allez vous farcir de billets, d'assignats:
Vous serez les croupiers du chef de la finance,
Peut-être même aussi de messieurs des États.
Amis, certainement, dans le temps où nous sommes,
Vous êtes ce qu'on doit appeller de grands hommes.
Aussi vous voilà surs d'avoir votre tombeau
A côté du cercueil du fameux Mirabeau;
Et pour vous le prouver, il faut que l'on propose
De rendre un grand décrèt d'après ma motion,
C'est qu'au plus tard, demain, tous les deux morts ou mon,
Dans son caveau funèbre en pompe on vous dépose.

* Ledit Lavoisier assure dans sa lettre que, tandis qu'une foule d'honnêtes gens meurent de faim et sont privés d'appointements, il ne peut se résoudre à en recevoir de doubles, c'est-à-dire a être payé au trésor royal et à la régie des Poudres. Sa modestie lui fait préferer ceux de cette régie, parcequ'ils sont plus médiocres, et que la médiocrité est ce qui lui convient de mieux. La révolution a fait d'étranges miracles! car le savant financier ne pense ainsi qu'à dater de cette époque. Non-seulement il a trouvé très-juste pour des services tous simples d'être payé double pendant plus de vingt ans aux fermes et à la régie, mais il n'a pas dédaigné de ravir aux véritables savans de l'Académie des Sciences une pension de mille écus, dont il a bien voulu se résoudre à jouir, malgré sa répugnance pour l'argent; mais il le fallait absolument pour prouver qu'il était véritable confrère de ses confrères. Dans ce beau siècle où la vertu anime tout, produit tout, renverse tout, qu'il serait digne de la sublime générosité de M. Lavoisier d'abandonner à sa généreuse nation, à ce bon peuple parmi lequel il était si digne de naître, tout ce qu'il a reçu de trop depuis qu'il est double, triple et même quadruple! car il est aussi de la Caisse d'Escompte.

LAVOISIER'S RELIGIOUS VIEWS

It has usually been assumed that Lavoisier was orthodox in his religion, and his most recent biographer[7] perpetuates the idea. This view seems to have been originally emitted by his first and most important biographer, the painstaking Grimaux[8] who, as we shall see, deliberately suppressed evidence to the contrary. The facts concerning this perversion of history are as follows.

In 1892 James Guillaume[9] was visiting Grimaux, who was a distant relative, and discussed with him the question of Lavoisier's activities during the troubled time of the Revolution. Grimaux was at this time in possession of the masses of papers left by the great chemist and loaned to him by the heirs. He allowed Guillaume to browse among them when the latter was excited to find Lavoisier's autographed comments relating to Talleyrand's paper on education which its author had sent him for criticism. These comments give, as I shall show, a clear view of Lavoisier's unorthodoxy, but it is worth noting that Grimaux at that time refused to allow Guillaume to publish them as he felt that they might give offense to the heirs who presumably would not have liked to have these unorthodox views of their illustrious forebear made public. This lack of courage on the part of Grimaux is rather surprising for he was later to incur the great displeasure of Lavoisier's heirs by courageously supporting Dreyfus in the famous trial controversy. Two years later Guillaume published his "Procès-verbaux du Comité d'Instruction publique de la Convention Nationale" (Paris, 1894), and to his surprise Grimaux then gave him permission to include as much as he wished of Lavoisier's comments in the introduction to that work.

The manuscript by Lavoisier consisted of notes headed "Reflexions sur le plan d'instruction publique présenté à l'Assemblée nationale en septembre 1791, par M. Talleyrand-Périgord, ancien évêque d'Autun," and the text of the first two pages reads in English translation as follows:

Public education as it exists in almost the whole of Europe has been devised not with the intention of training citizens but for the purpose of producing priests, monks, and theologians. The spirit of the Church has always been set against all innovation and, because the early Christians spoke and prayed in Latin, because the majority of the fathers of the Church wrote Latin, it has been held that in all countries and however the spoken language might become changed, praying must, for all time, be carried out in Latin. Hence arose the educational system of Europe which is almost entirely directed towards teaching in the Latin tongue.

If one considers all the public statements, all the metaphysical and moral theses upheld in the various colleges, it will be seen that they are nothing more than an introduction to theology, that theology was the science *par excellence* which was intended to complete one's education, and to which the whole system of education led.

As public education was intended solely for the purpose of training priests, for many years it has been the custom to train in colleges only those destined for a priestly career; and as the

[7] McKie, Douglas, "Antoine Lavoisier, Scientist, Economist, Social Reformer," New York, 1952, p. 256.

[8] Grimaux, E., *op. cit.*, p. 53.

[9] Guillaume has recorded the incident in his "Études révolutionnaires," 1st series, Paris, 1908, pp. 354 ff.

Church was the road leading to honor and fortune, Catholic nations have naturally been divided into two classes—the churchmen, among whom were concentrated the learned, and the illiterates, who made up almost the whole of the rest of the nation. It is thus that, originally by hazard, but latterly by very clever planning, all that might have tended to destroy errors and prejudice has been concentrated in the hands of those whose interests were the maintenance of those errors and prejudices.

This period, made up of 16 centuries which were almost totally lost to reason and philosophy, and during which all forward progress in the human mind was completely suspended, during which there were even often backward steps, will always be memorable in the history of mankind, and one can judge how important in the eyes of posterity will be those who have overturned these antique relics of ignorance and barbarism.

It does not seem to have been noticed so far that Lavoisier, at about the same time but under different circumstances, gave another expression of his anticlerical feelings. His collected works contain[10] the supplement to a memoir he wrote as *régisseur des poudres* late in 1789, or in January, 1790, for the National Assembly. In this brief note he calls the attention of the legislature to the conditions prevailing in the papal enclaves in the Provence (Avignon and the county of Venaissin). He complains that their existence was not only illegal but damaging to France because, despite permanent surveillance, powder and other contraband were constantly smuggled over their borders. He strongly urges the National Assembly to consider the reannexation of these territories to the kingdom in the following words: "La réunion de cette souveraineté à la France mérite toute l'attention de l'Assemblée nationale et ne serait qu'une suite de son décret sur les biens ecclésiastiques;..." This sentence certainly proves that he was not opposed to sequestration and, in any case, that he put economic and patriotic considerations before his allegiance to the Church as such.

One may deduce that, although Lavoisier conformed with the religious proprieties as far as the customs of the times decreed, he was obviously aware of the stultifying part which the Church had played in France's development. Atheism would not have held any attractions for him, but neither would a narrow and stifling Church which consistently attempted to stop the march of progress.

NO NEED FOR SCIENTISTS

The legendary saying, "The republic has no need of scientists—let justice take its course," has been attributed in varying forms to different officials connected with the trial of Lavoisier and his colleagues of the Ferme-générale by numerous writers and scholars. Recently it was given extensive circulation by the science editor of the *New York Times*.[11] Almost half a century ago James Guillaume[12] carefully sifted the facts and demonstrated the mythical nature of the saying in any of its forms, and I am much indebted to him for his painstaking and pioneer researches. As no adequate survey on the subject has appeared in the English language, this presentation is here offered.

We may start by noting that the saying has been attributed variously to Coffinhal, Dumas, and Fouquier-Tinville—if it was indeed uttered at Lavoisier's trial, it can only have been by Coffinhal, who was the only one of the three present. As we shall see, however, it is pretty certain that it was never uttered.

An eyewitness account of Lavoisier's trial was published by the grandson of one of the other defendants[13] and does not fail to give a number of by-the-way anecdotes. No mention is made, however, of any request by Lavoisier for a delay in his execution or of any such saying being uttered by the court. The earliest biographical account of Lavoisier was written by his ex-colleague of the Royal Academy of Sciences, the astronomer, Lalande, and appeared in the year An IV (1796),[14] giving an account of the failure of the Bureau de Consultation to save him but not mentioning any appeal by Lavoisier for a temporary reprieve or the reply of the court. The fact that these reliable sources omit reference to the incident is significant.

Now let us consider the early occasions on which the phrase seems to have been recorded. On the 15 Thermidor An IV (August 2, 1796), a ceremony was held by the Lycée des Arts in memory of Lavoisier. On this occasion, Fourcroy[15] made an apology for his own failure to save Lavoisier and paid the departed genius a fulsome tribute. A rather nauseating poem by Désaudray, set to music, and praising Lavoisier in an extravagant manner, was also delivered.[16] Both tributes contain differing versions of the dictum that the republic has no need of scientists and attribute its origin to Lavoisier's trial. Three years later we find Quénard[17] giving a new version in which Lavoisier's request for a stay of execution is met with the reply, "Le peuple n'a pas besoin de chimie." A few years later, Desessarts[18] repeated the story but, although he makes it seem more probable by attributing it to Coffinhal, who was the only person who could have uttered the saying, he embroiders it and makes the answer given Lavoisier's request for a temporary reprieve to have been, "La République n'a pas besoin de savants et de chimistes. Le cours de la justice ne peut être suspendu."

Two years later a much more reliable and scientifically minded author than Quénard, Désaudray, or Desessarts was to speak of the death of Lavoisier. This was Biot,[19] who was fond of recounting anecdotes

[10] "Oeuvres de Lavoisier," Paris, 1892, vol. 5, pp. 711–3.

[11] KAEMPFFERT, WALDEMAR, *The New York Times Book Review*, November 9, 1952, p. 22.

[12] "Études révolutionnaires," 1st series, Paris, 1908.

[13] DELAHANTE, ADRIEN, "Une famille de finance au XVIIIme siècle," Paris, 1880.

[14] "Magasin Encylopédique," Vol. V, p. 174.

[15] "Notice sur la vie et les travaux de Lavoisier."

[16] "La mort de Lavoisier, hyérodrame mis en musique par le Citoyen Langlé," Paris, An IV.

[17] "Collection de portraits de la Révolution," Paris, An VII, Vol. 2.

[18] "Siècles littéraires de la France," Paris, An IX, Vol. 4.

[19] "Essai sur l'histoire générale des sciences pendant la Révolution française," An XI.

but fails completely to mention in his account of Lavoisier's tragic end either the demand for a reprieve or the reply of the court.

So far I have been content to mention only the earliest occasions on which the story seems to have been mentioned, together with a series of negative indications leading to doubts as to its authenticity. We now come to consider more positive indications.

In the spring of the An III (1795) and less than a year after Lavoisier's execution came the trial of Fouquier-Tinville and his colleagues. Numerous witnesses were only too willing to come forward and give testimony against the accused. The interrogatories attending the trial and condemnation of the farmers-general were brought up in detail on more than one occasion,[20,21] but we find no reference to the request for a delay or its refusal.

A further point, incidentally, should be made of the fact that an appeal for mercy, even of a temporary nature, is quite contrary to our knowledge of Lavoisier's character.

We are then left with the problem of whence came the original story, and James Guillaume[22] has run this down to the ex-bishop and conventionnel, Grégoire, who, seven months after the death of Lavoisier, wrote,[23] "Il faut transmettre à l'histoire un propos de Dumas, concernant une science dont les bienfaits incalculables s'appliquent à divers arts, et spécialement à celui de la guerre. Lavoisier témoignait le désir de ne monter que quinze jours plus tard à l'échafaud, afin de compléter des expériences utiles à la République. Dumas lui répond 'Nous n'avons plus besoin de chimistes.'"

LA SOCIÉTÉ DE 1789

Lavoisier was a member of the so-called Club de 1789 and read an important paper (August 29, 1790) at one of their meetings, devoted to a study of the *assignats*.[24] This was a body of men led by such people as Lafayette, Bailly, Mirabeau, Condorcet, Roederer, Dupont de Nemours, Talleyrand, La Rochefoucauld, and Sieyès, who had originally been members of the Club des Jacobins but who seceded when they felt the latter body's policies were being directed away from their own aims and objectives. Politically they hoped to see Louis XVI break with his ancient advisers, accept the Constitution, both in letter and spirit, re-establish order and discipline in the state, and rule as a constitutional monarch on the lines of the English kings. Economically they were mostly adherents of the doctrines expounded by the physiocrats; they believed in sound, orthodox financial measures and were opposed to the unsound makeshifts which were being used to avoid open bankruptcy of the state. The society was highly organized and at first met with considerable success; originally located in a fine house in the rue Richelieu, it soon moved to handsome quarters at No. 108 Palais-Royal. Its meetings were notable for the high caliber of the discussions; they were attended by the leading philosophers, academicians, literati, and financiers. The meetings were usually followed by a repast which, in those times of scarcity, was soon criticized for its sumptuousness. Although regarded as overly liberal and advanced politically by the extreme royalists, it has been suggested, without proof, by Louis Passy,[25] that the club was subsidized by the court. It was the subject of a satirical attack in the organ of the reactionaries, *Les Actes des Apôtres*.[26] Unfortunately the comparatively moderate tenor of its view was hardly likely to find favor with the mob which soon took control of the city of Paris and was led by the Club des Jacobins, who became determined to destroy the Club de 1789—in fact, by 1792 sometimes membership of the latter body was sufficient to render one liable to charges of antirevolutionary activities, and a comparatively recent publication[27] devotes a long description to the Club in an account of contemporary antirevolutionary organizations.

As events moved forward on the state of the Revolution, the Club de 1789 came more and more under the concentrated fire of the Club des Jacobins and the Club des Cordeliers, which were two violently left-wing organizations whose powers over the Assemblée Nationale became ever greater. In June, 1790, the Club had given a reception[28] to celebrate the birth (June 17, 1790) of the Assemblée Nationale which was attended by the Mayor of Paris (Bailly), the Commander-in-chief of the National Guard (Lafayette), and the President of the Assemblée (Sieyès), and the most influential Mirabeau, Talleyrand, and Condorcet, all of whom were members of the Club de 1789. This seems to have been the time of the Club's greatest prestige and power. By early 1789 the attacks of the left-wing partisans were taking effect, and by the end of that year the Club was in disrepute and dissolved. The right-wing Club des Feuillants was formed at the end of 1791, and many of those members of the Club de 1789 who had not gone to join the more revolutionary organizations joined this body; Lavoisier was not among these. It may be assumed that he felt sympathy for neither the Feuillants nor the Jacobins.

LA SOCIÉTÉ DES AMIS DES NOIRS

In 1788 was founded an organization whose avowed objects[29] were the suppression of the slave trade and eventual liberation of all slaves in the French colonies. The president (in 1789) was Condorcet and the founder, Brissot, who later became leader of the Girondins and

[20] Buchez and Roux, "Histoire Parlementaire," Vol. 35, pp. 124–5.

[21] *Moniteur* of 21 Floréal An III, reporting the session of the Convention of 16 Floréal.

[22] *op. cit.*, p. 153.

[23] "Troisième rapport sur le vandalisme lu à la Convention le 24 frimaire," An III.

[24] "Réflexions sur les assignats et sur la question de la dette exigible ou arriérée."

[25] Frochot, Paris, 1874, pp. 48–9.

[26] Third *version*, No. 87.

[27] Challamel, Augustin, *op. cit.*

[28] *Moniteur universel*, June 22, 1790.

[29] "Réglements de la Société des Amis des Noirs," n.p., n.d., Paris, 1788.

was finally executed by the extremists. According to a list of 94 members[30] ranged in the order of their admission, we find Lavoisier's name figured as No. 49. Among Lavoisier's fellow-members we see the publisher of his "Traité Elémentaire de Chimie," Cuchet; his colleagues from the Ferme-Générale, De Montcloux, Du Vancel, De Saint Alphonse, and De Sannois; from the Académie des Sciences, the Marquis de Condorcet, the Duc de la Rochefoucauld; the president of the Société Philanthropique, of which Lavoisier was a member, the Duc de Charost; the Commander-in-chief of the National Guard, the Marquis de Lafayette; and Mr. Short, Secretary at the Embassy of the United States of America.

It might be expected that the humanitarian aims of the Society would have appealed to almost all classes of the kingdom, but such was not the case, and it became the object of bitter attack and acrimonious polemic. The reasons for this were economic and were set out by the English agriculturist, Arthur Young.[31]

John Adolphus has given a long but biased account[32] in his biography of Brissot of the aims and activities of the Société des Amis des Noirs. He suggests that Brissot, Condorcet, Grégoire, and Petion were all suborned with large sums of money raised by the mulattoes in St. Domingo and that this, rather than lofty principles, explains the support given by these legislators to the motion for abolishing slavery—which was also strongly supported by Mirabeau and Robespierre.

At this period the negroes rose in St. Domingo and riots and bloody massacres followed. Adolphus attributes the responsibility for these disturbances to the activities of the Society, and there is plenty of evidence that these charges were frequently leveled at this body by those who disagreed with their objectives.

The Abbé Barruel in a work[33] devoted largely to trying to prove the correctness of his thesis that the French Revolution was initiated and developed by the Freemasons, spends a number of pages attempting to show that the Société des Amis des Noirs was a sinister body of Freemasons who used it to mask their revolutionary activities. His bigoted account does not ring true and appears to the present writer unsupported by any evidence. It must be admitted, however, that the leading lights of the Société were Freemasons, and this raises the question of Lavoisier's possible membership in the order. No evidence has been found that Lavoisier ever belonged to any of the Paris lodges, and the only indication supporting the suggestion seems to be the fact that many of his close associates were members, and the language used by him in his "Réflexions sur l'instruction publique," which is unlike the style of the rest of his writings and in many ways reminiscent of the Masonic ritual.

In his "Mémoires"[34] Brissot relates at some length the objects and reasons which led to the founding of the Amis des Noirs. It was, according to him, a visit to England and a meeting with Granville Sharp, who had founded an organization to bring about the abolition of the slave trade, which started him off on this track. Brissot was a close acquaintance of Marat, and in his "Mémoires"[35] he relates an anecdote concerning Marat and Lavoisier as well as a number of other references to Lavoisier which do not seem to have been noticed before, and which we shall therefore quote in full in a free English translation:

I remembered Marat's farce with the physician Charles, a worthy man who shared the honor of the invention of the Montgolfier balloons because he constructed the aerostat which was used in the famous balloon experiments, and who, by order of the last king, saw his name engraved next to that of the brothers Montgolfier on the medal commemorating their invention. I avoided suggesting to Fourcroy that he should mix with a scientist as terrible and as touchy as Marat who used to threaten his opponents with death. Despite his hatred against the farmers-general and the academicians, he also wished that I should introduce him to Lavoisier. I plainly turned him down saying that I hardly knew the eminent chemist who was a friend of Mentelle but not of mine, and that even Mentelle himself was not on sufficiently close terms with him to introduce a stranger to him. Marat did not believe me at all. What I had told him was, nevertheless, true. I had never met Lavoisier at that time; I had a high esteem for his work and for his scientific zeal, but I was not enough of a scientist myself that I could have gone to the parties which were held at his house, and at which only distinguished scientists could be seen. It was not in keeping with my character to appear in his drawing room as a man of the world. Because I did not have relations of friendship with Lavoisier, Marat concluded that I should come out as his enemy, and he asked me to approve an article of his (for my periodical, the *Patriote français*) in which he contended that the academician had wrongfully appropriated, as his own, discoveries actually made by Cavendish. I did not have Lavoisier's works before me and, therefore, I could not appraise the correctness of the accusation; but I wanted Lavoisier himself to be the judge. He demonstrated how unjust this accusation was by proving that he had always given credit to those from whom he ever had derived anything. The same consideration was not always shown on his account, he said in that connection to Mentelle, whom he told that experiments and theories which he had communicated to the Academy since 1777 were presented as something new in 1779. These communications were related to the discovery of the decomposition of water; and his right to them could not be contested because Lavoisier had taken the precaution of having them signed at the time by the secretary [of the Academy]. I don't know whether this fact is generally known.

Lavoisier, to whom I believed to have thus given proof of my esteem and respect as a chemist, has regarded me since then as one of his enemies.[36] It is true, I did not think very much of his

[30] "Tableau des Membres de la Société des Amis des Noirs, Année 1789," n.p., n.d., Paris, 1789.

[31] "Travels (in France) during the years 1787, 1788 and 1789," Bury St. Edmund's, 1792, p. 275.

[32] "Biographical Memoirs of the French Revolution," London, 1799, Vol. 1, pp. 226–30.

[33] "Mémoires pour servir à l'histoire du Jacobinisme," Hamburg, 1798, Vol. 2, pp. 462 ff.

[34] "Mémoires de Brissot. . . publiés par son fils: avec des notes et des éclaircissements historiques par M. F. de Montrol," Paris, 1830–32, Vol. 3, pp. 1 ff.

[35] *Op. cit.*, Vol. 2, pp. 8 ff.

[36] Brissot actually had attacked Lavoisier viciously in 1791. His "Mémoires" contain (Vol 4, pp. 20–1) a short biographical sketch of Lavoisier which he then had drawn up in collaboration with Mirabeau and Clavières, and which reads in English translation as follows:

administrative and financial knowledge, or rather, I regarded him as belonging to that class of people who are naturally opposed to the public interest. I did not approve of his nomination as substitute deputy to the National Assembly and still less of that as administrator of the Treasury. Lavoisier, the farmer-general and president of that discount bank, the superior officers of which had for a long time tried to get control of the finances of the state, and who, in the interest of their notes, had all written against the assignats, seemed to me out of place in the administration of the treasury and unable to vote freely against ministers to whom he was subordinated. I attacked his nomination and more sharply still that of Devaines, Rouilli, and Huber, who were to be his associates. . . .

To Lavoisier was ascribed the scheme of walls around Paris, a scheme which was executed to our disgrace, to the discredit of the architect and against good taste, and only for the profit of certain contractors for whom it was a means of enriching themselves. If this fact is true, it betrayed his intelligence and his patriotism; because, even under the pretext that this was done under a despotic government, he had no authority to create manacles, bridle reins, and jails for his equals. Besides, he was a farmer-general; was this a reason for hoping to find him a restorer of the liberties of the people and of their finances? As Lavoisier's colleague in the Société des Amis des Noirs, I would have wished to be able but to praise him; I found him of prepossessing manners and kindly disposition, his name rightly famous in the sciences. I uphold his ingenious system of pure air; I like the way in which he explains all the phenomena which Stahl and the English can only solve with the help of their imaginary phlogiston which Fourcroy has so forcefully destroyed. But, as it would be very ridiculous to put a Colbert or a Davenau at the head of a school of chemistry, it would not seem to be less strange to find a minister of finance among the furnaces of his laboratory, at any rate not if this chemist has not proved his financial ability. In other words, how has Lavoisier proved himself?

In my sharp attacks against the others, and even against the honest and honorable Condorcet, I spoke of Lavoisier only with the consideration that I wanted to show for his personal character. I saw from a letter he wrote me how hard my frankness appeared to him to be; but we would not have been worthy of freedom if we had been softly indulgent against each other, and if we had sacrificed for small considerations the great interests of the people.

Lavoisier's note: "M. Lavoisier has the honor to send to M. Brissot-Warville a copy of the letter he wrote to M. Delessart in reply to one which informed him of his nomination as commissioner in the administration of the treasury: he hopes that he will be good enough to insert it in the *Patriote français*.

"M. Lavoisier would have liked to be better known by Mr. Brissot-Warville, who would then have spared him the epithets which he did not deserve. He hopes that his conduct at all times and under all circumstances will always prove that nobody is more firmly attached to the principles of the revolution than he is."

Letter from M. Lavoisier to minister Delessart: "Sir, by submitting myself to the king's orders and devoting myself to laborious duties which are perhaps beyond my powers, in short, by giving up the kind of life which I had laid out for myself, I believe myself to be able to prove as strongly as I possibly can how devoted I am to the public cause.

"As a price for these sacrifices, I only ask for one favor, that is that I be permitted to fulfill the new duties which have been entrusted to me without compensation. The salary which I have as régisseur des poudres, particularly because it is moderate, fits in with my standard of life, with my tastes, my needs, and at a moment when so many honest citizens lose their positions, I could for nothing in the world consent to profit from a double salary.

"Called by the king's confidence to fulfill important public functions, the commanding oath I took as substitute deputy to the National Assembly on February 4 of last year seems to take on ever-increasing importance in my eyes; this ever-memorable event, when all true Frenchmen, following the example set by a citizen king and the example of the restorer of French freedom, rallied under the banner of the constitution and swore to defend it to their last breath.

"Whatever duties I shall ever be asked to perform, this burst of patriotism, which I so keenly shared, which from the National Assembly went out over the whole of France, will never slip from my memory, and my whole life will only be the constant fulfillment of the obligation which I took upon me."*

"Farmer general and academician, two titles for the encouragement of despotism; besides he is the author of the scheme to build walls around Paris. Hissed at in Blois when he presented himself for the elections, he only obtained votes out of charity. Lavoisier became a chemist, he would have become an alchemist if he would have followed only his inextinguishable thirst for gold. But he and his associates have found safer means to satisfy this thirst; the excessive soaking of the tobacco and the speculative and monopolistic purchase of grains. France is indebted to them for eight or ten famines."

* [Original footnote by F. de Montrol] Brissot by no means wished to insert this letter in his periodical. Among some other objections, he answered Lavoisier that an official did not have the right to refuse a salary, that this would give a sinister example if it should be repeated, because it would place all public offices in the hands of the rich. Whatever opinion one may have about the right Lavoisier had or did not have to refuse the salary of his position, we believe that his note and his letter do honor equally to his generosity and to his patriotism. It was he who had the name of the public treasury changed into that of national treasury. He became soon afterwards one of the most distinguished victims of this revolution whose principles he gloried in adopting. Condemned to death with twenty-four farmers-general, he only asked for one favor from his judges, that is, that he should be allowed to live a few days longer so that he would have time to complete a discovery important for the advancement of science; he received the reply that France had no need any more for scientists, and he was sent to the scaffold.

THE DEFINITION OF OSMOTIC PRESSURE[1]

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IN THE teaching of physiology, and to a lesser but still important extent in the teaching of physiological chemistry, much stress is placed on the concept of osmotic pressure. This concept is applied in physiology and in clinical medicine in the description of the formation of glomerular fluid in the kidneys, in the description of the passage of water across capillary blood vessels elsewhere in the body, and in studies of shock, of liver disease, of heart disease, and of kidney disease. Incorporated in Starling's hypothesis on the factors regulating the distribution of water between the blood plasma and the interstitial spaces (*1*), it is a concept of paramount importance. It is unfortunately the one concept taken from physical chemistry which has been the most widely misunderstood.

A specific example may be considered in brief detail. In nearly all textbooks of physiology it is stated that the rate of formation of glomerular fluid in the kidney is proportional to the "net" or "effective filtration pressure." This proposition, which is fundamental to renal physiology, is frequently expressed as:

$$\text{GFR} = k(P'' - P' - \pi'' + \pi') \qquad (1)$$

where GFR is the rate of formation of glomerular fluid (generally called "glomerular filtration rate"); k is a proportionality coefficient; the double primes refer to the blood side and the single primes to the glomerular fluid side of the glomerular capillary walls; P is actual hydraulic pressure, and π denotes "colloid osmotic pressure." In effect, the osmotic pressure is subtracted from the actual hydraulic pressure in order to obtain a value for the "net" or "effective filtration pressure." The osmotic pressure is used as if it were a hydraulic pressure which actually existed in the body. (For a *derivation* based on chemical potentials of an expression similar to that given above see (*2*).)

It is appropriate at this point to quote Guggenheim (*3*):

> The osmotic pressure is by definition a pressure that must be applied to the solution to bring it into a certain equilibrium condition. It is not a pressure exerted by the solution or part of the solution at its normal low pressure. It is, in fact, analogous to the freezing-point of a solution, which has no relation to the actual temperature of the solution, but is the temperature to which it must be brought to reach a certain equilibrium state. The osmotic pressure is nevertheless sometimes defined as the pressure exerted on a membrane, permeable only to the solvent, separating the solution from pure solvent. This definition, unless carefully qualified, is incorrect. Another definition sometimes given is the pressure exerted by the solute molecules on a membrane permeable only to the solvent. This definition is still more incorrect than the last.

On the basis of Guggenheim's statement, subtraction of the osmotic pressure from the actual pressure to obtain the "net" or "effective filtration pressure" is equivalent to the subtraction of the freezing point of a solution from its actual temperature to obtain what would be called the "net" or "effective temperature."

As clearly indicated in most textbooks of physical chemistry and of thermodynamics (*4–15*), the osmotic pressure as determined in conventional aqueous systems is a measure of the effects of other substances on the properties of water rather than a direct measure of the intrinsic properties of the other substances. Nonetheless, reference is made to the osmotic pressure of proteins, of protein solutions, and of electrolytes and non-electrolytes. Terms such as "oncotic pressure" (from the Greek, *ομκος*, swelling), "osmols," "osmolar concentration," "osmotically active," "osmotic integrity," and "osmotic coefficients" are used; such terms do not suggest reference to the properties of water. More confusing are the following statements taken from textbooks of physiology and of physiological chemistry (and from one textbook of thermodynamics):

"I shall continue to use the term 'osmotic pressure,' meaning thereby that property of solutions conferred upon them by the kinetic energy of the solutes." "Equation . . . permits another interpretation of osmotic pressure: . . . it can also be regarded as a tension or suction pulling the solvent back into the solution across the semipermeable membrane." ". . . were the hydrostatic pressure reduced to zero all the water of the interstitial fluid would theoretically be drawn back into the vascular tree by the protein osmotic pressure." "The protein molecules therefore exert an osmotic pressure, which may draw fluid and salts into the system. . . ." "We can say, therefore, that the effective osmotic pressure of the plasma is usually due solely to the plasma proteins." "The total osmotic pressure of plasma is about 6.5 atmospheres or 4940 mm. of mercury. This is a suction and is almost balanced by a similar osmotic pressure (suction) of the tissue fluids bathing the capillary."

Perhaps the situation is accurately summed up by a physiologist:[3] "At a time when physiologists set great

[1] Supported by a grant from the Life Insurance Medical Research Fund.

[2] Markle Scholar in Medical Sciences.

[3] As a matter of point, most physiologists appear to have adopted van't Hoff's views on osmotic pressure, in spite of the fact that these views have long since been abandoned by nearly all physical chemists and thermodynamicists. For an interesting reminder of the early divergence of opinion among physical

store by the austere definitions of the physical chemists it is well to recall that the former have pre-empted the term 'osmotic pressure.' "

Although quite adequate definitions of osmotic pressure and derivations of expressions for osmotic pressure are given in many texts (see particularly *3, 7, 10, 11, 13, 14, 15*), these texts are not generally or willingly consulted by medical students. Most textbooks of physiology and too many textbooks of biochemistry are grossly inadequate or grossly incorrect on the subject. It is hoped that this article will bring to the attention of those who teach chemistry to pre-medical students or physiological chemistry to medical students the need for much greater emphasis in setting the matter straight at least for future generations of physicians.

DERIVATIONS

An Expression for Osmotic Pressure. The following derivation is patterned on that given by Scatchard (*10, 18*). Consider an isothermal system divided into two compartments by a membrane which prevents the transfer of one or more components from one compartment to another. In order that equilibrium with respect to water obtain it is not necessary either that the pressure on the two compartments be equal or that the composition of the solutions in the two compartments be identical. The only requirement for equilibrium with respect to water to obtain is that the chemical potentials of water in the two compartments be equal. It is not necessary that the chemical potentials of other substances be equal. Let the system contain but two components—water which can cross the membrane and a protein which cannot. Let the compartment containing protein be distinguished by double primes and the protein-free compartment be distinguished by single primes. The condition of equilibrium is that $\mu_{H_2O}'' = \mu_{H_2O}'$. We wish to find *an expression for the difference of the chemical potentials of water when the pressures are equal and also that pressure difference which is necessary to establish equilibrium.* By definition:

$$\left(\frac{\partial \mu}{\partial P}\right)_{T,N,f} = \bar{V}_{H_2O} \qquad (2)$$

where the subscripts to the parentheses indicate that these variables are held constant. μ is the chemical potential of water, P is pressure, T is absolute temperature, N is mol fraction, f is mol fraction activity coefficient, and $\bar{V}_{H_2O}$ is the partial molal volume of water. On integration of (2) and taking to the appropriate limits there is obtained for the difference of the chemical potentials of water at pressure P'' and at pressure P':

$$\mu''_{p''} - \mu'_{p'} = \bar{V}_{H_2O}\,(P'' - P') \qquad (3)$$

(It is assumed that $\bar{V}_{H_2O}$ is constant over the range of pressure considered; this is equivalent to the assumption that water is incompressible over this range.)

Chemical potential is related to composition by the expression:

$$\left(\frac{\partial \mu}{\partial \ln N_{H_2O} f_{H_2O}}\right)_{P,T} = RT \qquad (4)$$

where ln denotes natural logarithm and R is the gas constant.

On integration of (4) and on taking to the appropriate limits there is obtained:

$$\mu''_{p''} - \mu'_{p'} = RT \ln \frac{N_{H_2O}''\, f_{H_2O}''}{N_{H_2O}'\, f_{H_2O}'} \qquad (5)$$

Choose a value for $P''-P'$ such that equilibrium obtains. We then have:

$$\mu'_{p'} = \mu''_{p''}$$

and may therefore write for (3):

$$\mu'_{p'} - \mu''_{p'} = \bar{V}_{H_2O}\,(P'' - P') \qquad (6)$$

Hence, combining (5) and (6) we have:

$$\mu''_{p''} - \mu'_{p'} = -\bar{V}_{H_2O}\,(P'' - P') = RT \ln \frac{N_{H_2O}''\, f_{H_2O}''}{N_{H_2O}'\, f_{H_2O}'}$$

On rearrangement this gives:

$$P'' - P' = -\frac{RT}{\bar{V}_{H_2O}} \ln \frac{N_{H_2O}''\, f_{H_2O}''}{N_{H_2O}'\, f_{H_2O}'} = \pi$$

where π is the osmotic pressure: that pressure difference which must be imposed in order to establish equilibrium.

Van't Hoff law. If the protein solution is so dilute that it may be considered ideal, then $f_{H_2O}'' = f_{H_2O}' = 1$. But since one compartment contains no protein, $N_{H_2O}' = 1$; also $N_{H_2O}'' + N_{prot}'' = 1$. Hence we may write:

$$P'' - P' = -\frac{RT}{\bar{V}_{H_2O}} \ln (1 - N_{prot}'')$$

But $-\ln(1 - N_{prot}'')$ approaches N_{prot}'' for N_{prot}'' small. Hence, on further simplification:

$$P'' - P' = \frac{N_{prot}''}{\bar{V}_{H_2O}} \cdot RT$$

By definition

$$N_{prot}'' = \frac{n_{prot}''}{n_{H_2O}'' + n_{prot}''}$$

where the n's denote the number of mols. From this last expression

$$\frac{N_{prot}''}{\bar{V}_{H_2O}} = \frac{n_{prot}''}{n_{H_2O}'' + n_{prot}''} \cdot \frac{1}{\bar{V}_{H_2O}}$$

Now n_{prot}'' is much smaller than n_{H_2O}''. We may therefore write

$$\frac{N_{prot}''}{\bar{V}_{H_2O}} = \frac{n_{prot}''}{n_{H_2O}'' \cdot \bar{V}_{H_2O}}$$

chemists see the discussion on osmotic pressure of the Faraday Society [*Trans. Faraday Soc.*, **13**, 123 ff. (1917–18)]. Opinion among physiologists has not been unanimous. One of the most eminent, J. S. Haldane, made at least two pleas for the correct definition and the correct use of the term "osmotic pressure" (*16, 17*). The pleas appear to have been largely ignored by his colleagues.

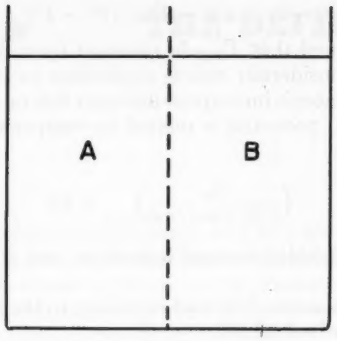

Figure 1

But, again by definition, $n_{H_2O}'' \cdot \bar{V}_{H_2O}$ is the volume of water and accordingly:

$$\frac{N_{prot}''}{\bar{V}_{H_2O}} = C_{prot}''$$

where C_{prot}'' is the molar concentration of protein. Finally we obtain

$$P'' - P' = \pi = C_{prot}'' RT$$

This equation is quite analogous in form to the simple gas law. Much of the misunderstanding about osmotic pressure appears to have arisen from van't Hoff's unfortunate emphasis of the analogy. It is utter nonsense to suggest that the osmotic pressure is "exerted" by the molecules which cannot cross the membrane in analogy to gas molecules which bombard the walls of a container.[4] The derivation as given here should be used to emphasize the important fact that for very dilute solutions the pressure difference necessary to establish equilibrium with respect to water is proportional to the concentration of that constituent which cannot cross the membrane. But the lack of applicability of the simple relationship at higher concentrations should be stressed.

These derivations may serve to emphasize this important point: measurement of the osmotic pressure in conventional aqueous systems gives a measure of the relative properties of water containing different amounts of dissolved substances. It is not a direct measurement of a property of a protein.

It is therefore undesirable to speak of the osmotic pressure of proteins or of protein solutions. Such use of the term implies that a property of proteins is under consideration; *in actual fact the properties of water and the effects of dissolved substances such as proteins on these properties of water are under consideration.*

QUALITATIVE DEFINITION

In courses other than those in physical chemistry less exact descriptions must be used in order to convey the concepts to the students. Something along the lines of what follows may be found useful.

Consider a container, as in Figure 1, divided into two compartments A and B by a membrane permeable to water but not significantly permeable to protein. Both sides are filled to the same level with water. The pressures are the same on the two sides. No net shift of water will take place; therefore per unit time the number of molecules of water crossing from A to B is exactly equal to the number of water molecules crossing from B to A. Equilibrium obtains. Assume that the membrane is rigid. Impose a pressure difference across the membrane such that the pressure on B is greater than the pressure on A. There will be a net shift of water from B to A. The number of molecules crossing from B to A per unit time will be greater than the number of molecules crossing from A to B. As an approximation, we can consider that the average energy per molecule of water, originally equal in the two compartments when the pressures were equal, has now become greater in B than in A.

Assume now that the pressures are equal; equilibrium obtains. Introduce into B a certain quantity of a substance, such as a protein, which cannot cross the membrane. It will now be found that there is a net movement of water from A to B. The number of molecules going from A to B per unit time is greater than the number going from B to A. By analogy to the experiment above in which a pressure difference was imposed, we can consider that the average energy per molecule of water in B has been *decreased* by the introduction of the protein. However, equilibrium can be re-established if the pressure on B is increased relative to the pressure on A. This pressure difference can be adjusted so that no net movement of water occurs; equilibrium is re-established. We can consider that the average energy per molecule of water in B, originally equal to that in A and decreased by the introduction of protein in B, has been increased by the imposed increase in pressure so that the average energy per molecule of water is again equal on the two sides. When equilibrium obtains, the pressure difference imposed across the membrane is

[4] It may be pointed out that the general formulation applied here to solutions can also be applied to gaseous mixtures (*19, 20*). Consider a container divided by a rigid membrane into two compartments, A and B, of equal volumes; at the end of compartment B there is a movable piston. Into compartment A introduce hydrogen gas at a pressure P'; into compartment B introduce a mixture of hydrogen and argon such that the partial pressures, p_{H_2}'' and p_A'', are equal. Assume that these are perfect gases. The total pressure in compartment B, $P'' = p_{H_2}'' + p_A''$, is initially equal to P'. Assume that the membrane is permeable to hydrogen but not to argon. p_{H_2}'' is less than p_{H_2}'; therefore there will be net movement of hydrogen from compartment A to compartment B. (The condition for equilibrium with respect to hydrogen is that $\mu_{H_2}'' = \mu_{H_2}'$ or $p_{H_2}'' = p_{H_2}'$). Equilibrium can be established and the net movement of hydrogen prevented by moving the piston so that the volume of the compartment is halved, *i.e.*, so that P'' is doubled. p_{H_2}'' is now equal to P' and thereby equal to p_{H_2}. $P'' - P'$ may be called the "osmotic pressure." However, it is evident that the pressure difference, $P'' - P'$, cannot be ascribed to the bombardment of the walls of the container by the argon molecules. In this case, and in general, $P'' - P' = p_A''$, where p_A'' is the partial pressure of argon that obtained initially when the pressures, P'' and P', were equal. But, again, this does not signify that the pressure difference is "exerted" by the substance which does not cross the membrane.

the osmotic pressure. The experimentally determined relationship between the concentration of protein and the pressure difference necessary to establish equilibrium can be brought in at this point.

This type of qualitative description stresses the properties of water and may, as a matter of fact, be used to introduce the concept of chemical potentials on an elementary basis.

ILLUSTRATIVE EXPERIMENTS

Non-equilibrium Conditions. A suitable collodion or cellophane sac with a capacity of approximately 10 ml. is prepared. Into this is pipetted 5 ml. of a 4 per cent solution of human or bovine plasma albumin (or 5 ml. of plasma from discarded bank blood). A small beaker is then filled with a solution containing (ideally) all but the protein constituents of the solution inside the sac. The sac is then arranged in the beaker so that the level of the protein solution in the sac is the same as the level of the protein-free solution in the beaker (Figure 2*a*).

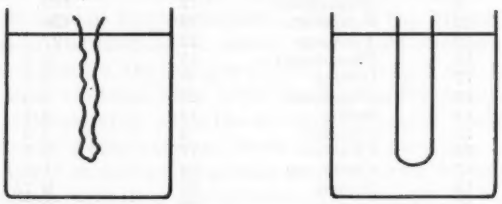

Figure 2

The pressures on the two sides of the membrane are equal. With time the net passage of water into the sac can be seen as the sac uncrinkles and becomes filled (Figure 2*b*). Quite obviously equilibrium does not obtain when the pressures are equal on the two sides. That the pressures are equal inside and outside the sac, as shown by the equal levels of the liquids, should be sufficient evidence that proteins do not "exert a pressure."

Equilibrium Conditions. The Measurement of Osmotic Pressure. Illustration of osmotic pressure in most textbooks is by means of an inverted thistle tube containing the protein solution, closed by a semipermeable membrane, and immersed in a protein-free solution. The height to which the protein solution rises is given as a measure of the osmotic pressure. It may be from such diagrams that there have originated such terms and phrases as "the proteins suck water" and "proteins exert a negative pressure."

A much more useful device—both pedagogically and for reasonably accurate measurements—is the Hepp osmometer or some modification thereof. In this apparatus the imposition of a pressure difference across the membrane is used to establish equilibrium; no significant net shift of water takes place. As adequate descriptions of such osmometers are readily available (*21*), the descriptions will not be repeated here.

In conclusion, it may be pointed out again that the concept of osmotic pressure, though extremely useful, has been widely misunderstood and misapplied, particularly in physiology and in other biological sciences; application of the concept to non-equilibrium situations is confusing and incorrect. The concept of chemical potentials can, however, be applied to many non-equilibrium problems of physical chemistry, of physiological chemistry, and of physiology. Such application permits a greater coordination of experimental facts and brings the facts into a logical system. Use of the concept of chemical potentials would be invaluable in the teaching of the effects of a given substance on the properties of another and in the dispelling of the confusion surrounding "osmotic pressure."

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THE ELEMENTARY COMPOSITION OF THE EARTH'S CRUST

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It is well known that that portion of the universe which is directly amenable to chemical analysis, *i. e.*, the earth's crust, is made up almost entirely of a relatively small assortment of the lighter elements. The heavier elements, that is, those past iron (atomic number, 26) in the periodic table, account for less than 0.2 per cent by weight. In Table 1 is presented the elementary composition of the earth's igneous rock (which makes up 95 per cent of the crust) as taken from the data presented in Gutenberg.[1] This table, or others like it, is familiar to most chemistry students.

Such tables, however, present the composition of the crust by weight and, therefore, introduce a bias in favor of the heavier elements and against the lighter ones. This bias is particularly marked in the case of hydrogen. Thus, the water molecule contains two hydrogen atoms to one of oxygen, yet the hydrogen content is only 11 per cent by weight. A more striking, though less familiar, example is the human body, in which hydrogen is usually presented as a comparatively minor component. In the body as a whole, the approximate percentage composition by weight is: oxygen, 60; carbon, 20; hydrogen, 10. On a dry weight basis, the figures are: carbon, 50; oxygen, 20; hydrogen, 10. Such figures effectively hide the fact that in either case, whole body or dry weight, over 60 per cent of the total number of atoms are hydrogen.

[1] Gutenberg, B., Editor, "Internal Constitution of the Earth," 2nd ed., Dover Publications, Inc., New York, 1951, p. 87.

TABLE 1
Elements in the Earth's Crust in Terms of Weight

Rank	*Element*	*Atomic number*	*Grams per 10,000 g.*
1	Oxygen	8	4659
2	Silicon	14	2772
3	Aluminum	13	813
4	Iron	26	501
5	Calcium	20	363
6	Sodium	11	285
7	Potassium	19	260
8	Magnesium	12	209
9	Titanium	22	63
10	Phosphorus	15	13
11	Hydrogen	1	13
12	Manganese	25	10
13	Sulfur	16	5.2
14	Barium	56	5.0
15	Chlorine	17	4.8
16	Chromium	24	3.7
17	Carbon	6	3.2
18	Fluorine	9	3.0
19	Zirconium	40	2.6
20	Nickel	28	2.0
21	Strontium	38	1.9
22	Vanadium	23	1.7
	All others		5.9

TABLE 2
Elements in the Earth's Crust in Terms of Atom Number

Rank	*Element*	*Atomic number*	*Atoms per 10,000 atoms*
1	Oxygen	8	6050
2	Silicon	14	2045
3	Aluminum	13	625
4	Hydrogen	1	270
5	Sodium	11	258
6	Calcium	20	189
7	Iron	26	187
8	Magnesium	12	179
9	Potassium	19	138
10	Titanium	22	27
11	Phosphorus	15	8.6
12	Carbon	6	5.5
13	Manganese	25	3.8
14	Sulfur	16	3.4
15	Fluorine	9	3.3
16	Chlorine	17	2.8
17	Chromium	24	1.5
18	Barium	56	0.75
19	Nickel	28	0.70
20	Vanadium	23	0.65
21	Zirconium	40	0.55
22	Strontium	38	0.45

Table 1 can be converted to relative atomic frequencies by dividing the figure for each element by its atomic weight. The minor elements, *i. e.*, those not listed by name in Table 1, may be ignored without serious error. By weight, they make up less than 0.06 per cent of the earth's crust, and since their average atomic weight is considerably higher than is that of the major elements, their percentage by atomic number is smaller still. From the values obtained for relative atomic frequencies, Table 2 can be constructed.

A comparison of Table 2 with Table 1 shows certain striking changes. The most important one, as is to be expected, involves hydrogen, which leaps from eleventh place by weight to fourth place by atomic number. (If the oceans were included in this calculation, the position of hydrogen would be still more remarkable since it would climb to third place, with an atom frequency two and a half times that of aluminum.) Carbon also shows up to much better advantage, and fluorine, which on a weight basis seems to be only two-thirds as common as chlorine, turns out to outnumber it atom-wise by a comfortable margin. The most

marked downward correction occurs in the case of iron which is five per cent of the earth's crust by weight, but less than two per cent by atomic number. A final point is that oxygen, which comprises nearly half the crust by weight, is still more disproportionately predominant by atomic number, making up 60 per cent of the total.

The earth's elementary composition, as shown in Table 2, is capable of a further refinement. Of the 22 elements listed, only six (aluminum, sodium, phosphorus, manganese, fluorine, and vanadium) consist of but a single nuclide species. The other 16 elements are mixtures of two or more isotopes, which are nuclide species that contain equal numbers of protons but varying numbers of neutrons. To be sure, the possession of equal numbers of protons insures the presence of equal numbers of electrons in the neutral atoms and hence of substantially equivalent chemical properties. This results in a failure to separate isotopes in geochemical processes, so that they almost invariably occur together in fixed proportions. In addition to this "relationship by propinquity," there is the subjective bias of the chemist, to whom, as a result of chemical manipulation, the isotopes C^{13} and C^{12} (which differ by a single neutron) seem blood brothers and scarcely to be differentiated, while the isotones C^{13} and N^{14} (which differ by a single proton) seem in no way related.

As far as nuclear properties are concerned, however, isotopes, with their equal proton contents, are no more closely related than are isotones, with their equal neutron contents. Any list of composition by elements, inasmuch as it lumps together isotopes and segregates isotones, introduces a bias. To eliminate this bias, the composition of the earth's crust should be calculated not by atomic number, but by nuclide number. Such a listing, including the 37 most frequently occurring nuclides in the earth's crust, is presented in Table 3. The figures in Table 3 can be obtained from those in Table 2 by making use of the fractional occurrence of the various nuclides within each elemental nuclide mixture.[2]

Again perspective changes. The nuclides O^{18} and O^{17} are generally looked upon as very minor components of the oxygen-nuclide mixture. The former occurs to an extent of only 0.20 per cent, while the corresponding figure for the latter is 0.041 per cent. Yet, as can be seen, there is more O^{18} in the earth's crust than there is phosphorus and almost as much O^{17} as there is chlorine. (This is not to deny that the oxygen isotopes are, nevertheless, many times more difficult to isolate in pure form than are phosphorus or chlorine, and are therefore *effectively* rarer.)

An interesting point to be made from Table 3 concerns the relative frequency of occurrence of different types of nuclides. Existing nuclides can be divided into four classes, depending on whether the protons and neutrons are odd or even in number. Of the naturally occurring nuclides (counting both the stable ones and the long-lived radioactive ones with half-lives of more than 10^8 years), 167 contain an even number of protons and an even number of neutrons; 53 contain an odd number of protons and an even number of neutrons; 56 contain an even number of protons and an odd number of neutrons; and 8 contain an odd number of protons and an odd number of neutrons.

[2] SULLIVAN, W. H., "Trilinear Chart of Nuclear Species," John Wiley & Sons, Inc., New York, 1949.

TABLE 3

Nuclide Species in the Earth's Crust in Terms of Nuclide Number

Rank	*Nuclide*	*Number of protons*	*Number of neutrons*	*Nuclides per 10,000 nuclides*
1	O^{16}	8	8	6036
2	Si^{28}	14	14	1887
3	Al^{27}	13	14	625
4	H^{1}	1	0	270
5	Na^{23}	11	12	258
6	Ca^{40}	20	20	183
7	Fe^{56}	26	30	171
8	Mg^{24}	12	12	141
9	K^{39}	19	20	129
10	Si^{29}	14	15	96
11	Si^{30}	14	16	62
12	Mg^{26}	12	14	20
13	Ti^{48}	22	26	20
14	Mg^{25}	12	13	18
15	O^{18}	8	10	12
16	Fe^{54}	26	28	11
17	K^{41}	19	22	9.2
18	P^{31}	15	16	8.6
19	C^{12}	6	6	5.4
20	Fe^{57}	26	31	4.1
21	Ca^{44}	20	24	3.9
22	Mn^{55}	25	30	3.8
23	F^{19}	9	10	3.3
24	S^{32}	16	16	3.2
25	O^{17}	8	9	2.5
26	Ti^{46}	22	24	2.1
27	Ti^{47}	22	25	2.1
28	Cl^{35}	17	18	2.1
29	Ti^{49}	22	27	1.5
30	Ti^{50}	22	28	1.4
31	Cr^{52}	24	28	1.3
32	Ca^{42}	20	22	1.2
33	Cl^{37}	17	20	0.7
34	V^{51}	23	28	0.7
35	Fe^{58}	26	32	0.6
36	Ba^{138}	56	82	0.5
37	Ni^{58}	28	30	0.5

From such a classification, it is commonly inferred that the "even-even" nuclides are most stable, or at least, were most easily brought into existence at that time in cosmic history during which the elements were formed. The "odd-odd" nuclides, on the other hand, are least stable, while the "odd-even" and "even-odd" nuclides are intermediate and roughly equivalent to one another in stability.

A somewhat different picture is obtained if, instead of the number of nuclide species in each group, the total occurrence of each group in the earth's crust is considered. Such data can be obtained from Table 3. It will be noted that none of the 37 nuclides there listed are "odd-odd." For the remaining groups (counting H^1 as an "odd-even" case) the atomic numbers per 10,000 are:

Even protons, even neutrons 8563
Odd protons, even neutrons 1311
Even protons, odd neutrons 124

The interesting thing here is the perhaps unexpected difference that has appeared between the "even-odd" and "odd-even" groups. While the earth's crust is certainly not a fair sampling of the nuclide distribution in the universe as a whole, we can still conclude that in this small portion of it, at any rate, an odd number of neutrons within a nucleus is more than ten times as effective in assuring the rarity of that particular nuclide than is an odd number of protons.

As a final point in passing, it can be seen that more than 75 per cent of all the "even-odd" nuclides in the crust are a single species, Si^{29}, the atoms of which account for just under one per cent of the crust by atomic number and 1.3 per cent by weight.

TEMPERATURE DEPENDENCE OF HEAT CAPACITY

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In thermochemical and thermodynamic calculations, a knowledge of the heat capacity of a substance as a function of temperature is frequently required. If the heat capacity can be expressed by a purely empirical power series equation

$$C_p = a + bT + cT^2 + dT^3 + \ldots \qquad (1)$$

the constants a, b, c, d must be derived from heat capacity data over the range of temperatures of interest with reference to the specific problem under consideration. This paper describes a method based on differential calculus for this purpose rather than the algebraic approach generally used. Thus for a *three* parameter power series equation as above, the first differential of C_p with respect to T defines the slope of the curve at any point T, *i. e.*,

$$dC_p/dT = b + 2cT \qquad (2)$$

The second differential

$$d^2C_p/dT^2 = 2c \qquad (3)$$

defines the rate of change of slope at any point T. It is evident from (3) that the latter is constant in this case. With these equations the constants a, b, and c are readily obtained from a knowledge of the heat capacities at three temperatures.

To reduce the use of letters and symbols to a minimum, let the following data for methane[1] be used for illustration of this method:

T (°K.)	300	600	900
C_p(cal/deg. mol)	8.55	12.55	16.21

The average slope over the temperature range 600–300° K. is simply $4.00/300 = 13.3 \times 10^{-3}$. This is also the slope at 450°K., *i. e.*, since the rate of change of slope is constant, the average slope in this temperature interval is

$$\tfrac{1}{2}[(dC_p/dT)_{300°} + (dC_p/dT)_{600°}] = b + 2c(450°)$$

or the slope of the curve at $T = 450$°K. Similarly, the average slope over the temperature range 900–600°K. is 12.2×10^{-3}, and this, as shown above, is also the slope at 750°K.

The rate of change of slope ($d^2 C_p/dT^2$) from 450° to 750°K. is $-(1.1_0 \times 10^{-3})/300 = -3.6_7 \times 10^{-6}$. In this instance, since the slope is decreasing, the rate of change of the slope is negative. Using this value in (3) above, c is found to be $-1.8_3 \times 10^{-6}$. Solving the first differential equation for b, and substituting for c, the value for b, obtained quite simply, is $14.9_5 \times 10^{-3}$. These values in (1) give 4.23_1 for the constant a. The equation for the heat capacity as a function of temperature for methane in the temperature interval 300–900°K. is given by

$$C_p = 4.23_1 + 14.9_5 \times 10^{-3}T - 1.8_3 \times 10^{-6}T^2$$

Thus, at 700°K., the heat capacity calculated by this relation is 13.8_1 cal/deg. mol, and the literature value (1) is 13.88, *i. e.*, the agreement is sufficient for most problems encountered.

The algebraic methods of solution, in this case, of three simultaneous equations rest on the elementary and basic procedure of elimination of the letters one by one from different pairs of equations until only one remains, or the more advanced and neater procedure of determinants, in which four determinants of the third order must be solved. The method described and illustrated above is basically more simple and less laborious than the algebraic methods for obtaining the equations expressing the heat capacity as a power series function of temperature.

[1] "Selected Values of Properties of Hydrocarbons," Circular C461, National Bureau of Standards, Washington, D. C., 1947.

AUTOMATIC EQUIPMENT FOR PRECIPITATION WITH H_2S

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THIS precipitation equipment is designed for individual use in qualitative analysis courses. It can also be used as a small Kipp unit, for the production of carbon dioxide, hydrogen, etc. The apparatus is economical, both in the equipment used to build it and in the quantity of HCl and FeS it consumes. Precipitation with H_2S is simplified considerably, eliminating the dangerous and noxious H_2S smell from the laboratory. The apparatus can be left ready for use at any time.

The equipment consists of four parts, a description of which follows:

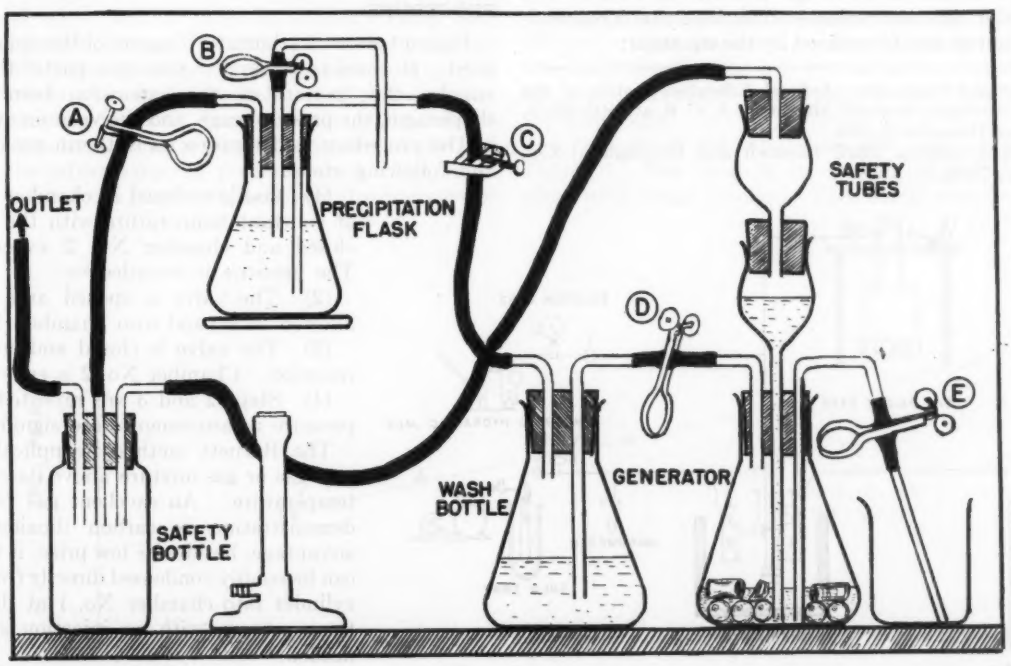
(1) Generator. Iron sulfide is placed on glass spheres in the flask, which is then charged with HCl (1:1) by opening the upper safety tube. A two-holed stopper can be used for the thistle tube, connecting this tube directly to the HCl source. The acid inflow can be regulated, by means of a pinch clamp or a glass stopcock. The expended HCl can be emptied by closing clamp *D*, waiting until the acid fills the safety tubes, and opening clamp *E*.

(2) Wash bottle.

(3) Precipitation flask. Clamp *B* can be opened to withdraw samples from the flask to determine if the precipitation has been complete. This is done in the following manner: Clamps *C* and *D* are left open and *A* is closed, waiting for the lower safety tube to fill with HCl. Clamp *B* is slowly opened, the first three drops are discarded, and the amount desired for analysis is then collected. Clamp *C* is closed, *A* is opened, and subsequently *B* is opened long enough to allow the contents of the tube to return to the flask.

(4) Safety bottle. This vessel should open to the exterior, through a rubber tube, to a hood or into a sink drain down which water is running.

As a precaution, whenever clamp *D* is closed *C* should also be shut to prevent passage of the contents of the precipitation flask into the wash bottle.



A DEMONSTRATION OF COMPRESSIBILITY MEASUREMENTS ON GASEOUS FLUIDS[1]

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MANY physicochemical laboratory experiments (*3*, *5*) at the undergraduate level have been proposed to demonstrate the gas laws. These experiments are carried out in glass systems at low pressures. As a consequence, they are unable to show the large deviations from ideality that occur at higher pressures, particularly in the neighborhood of the critical region. It was felt that an experiment performed on a gas slightly above its critical temperature and with a pressure range up to about 100 atmospheres would be helpful.

In order for the experiment to be successful, all of the measurements should be completed in a three-hour laboratory period and the equipment used should be relatively simple and inexpensive.

In general, the method employed for the determination of compressibility factors of gaseous systems is to confine a measured quantity of gas within a variable-volume container held at constant temperature; then through measurement of the pressure exerted by the gas under different volume conditions the compressibility factors are determined by the equation:

$$Z = \frac{PV}{nRT}$$

This method is highly reliable and is suitable for the determination of several isotherms with the same sample of gas. For the present purposes, however, it has the disadvantage of requiring direct and highly precise measurements of volume, mass, pressure, and temperature. All of these measurements cannot be carried out in a three-hour laboratory period.

In order to avoid the direct volume and mass measurements, the method of Burnett (*2*) was adopted and a highly simplified version of his apparatus was constructed and assembled. In this method the variable-volume container was substituted by two interconnected expansion chambers and the pressure was changed by a series of isothermal expansions from one chamber into the other. Thus, for one isotherm, the only measurements required were those of temperature and pressure.

PROCEDURE

Figure 1 shows a schematic diagram of the apparatus used. It consists of several principal parts: the gas supply, the thermostat, the expansion bomb, the diaphragm, the pressure gage, and the vacuum system.

The procedure to determine an isotherm consists of the following steps:

(1) Gas is enclosed in chamber No. 1 at constant temperature with the valve closed and chamber No. 2 evacuated. The pressure is recorded.

(2) The valve is opened and gas is allowed to expand into chamber No. 2.

(3) The valve is closed and pressure recorded. Chamber No. 2 is evacuated.

(4) Steps 2 and 3 are repeated until pressure measurements lose significance.

The Burnett method is applicable to any gas or gas mixture above its critical temperature. An excellent gas for the demonstration is carbon dioxide. Its advantage, besides its low price, is that it can be readily condensed directly from the cylinder into chamber No. 1 at dry ice temperatures, with no injection system needed.

Results of a typical demonstration are shown in Figure 2. In this figure three

[1] Presented before the Chemical Education Section of the Eighth Southwest Regional Meeting of A. C. S. at Little Rock, Arkansas, December 4, 1952.

[2] Present address: Shell Research and Development Co., Houston, Texas.

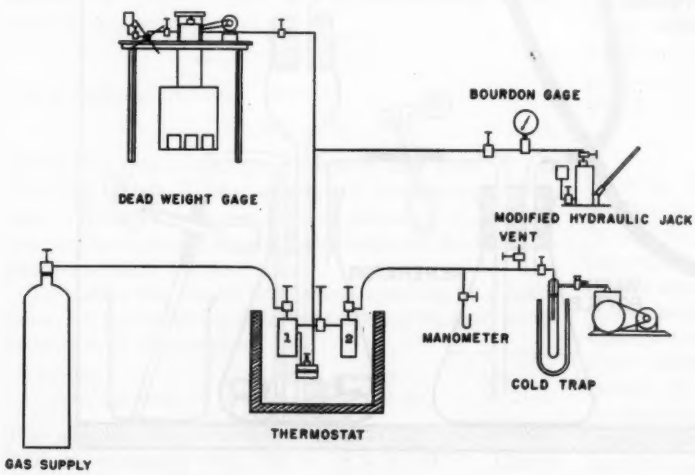

Figure 1

sets of data are plotted and compared with the results of Amagat (*1*). It can be observed that the measurements obtained using a dead-weight gage agree with those of Amagat within about two per cent. Those obtained with a very ordinary but previously calibrated Bourdon gage agree within five per cent. All results, however, illustrate quite well the large deviations from ideality of carbon dioxide.

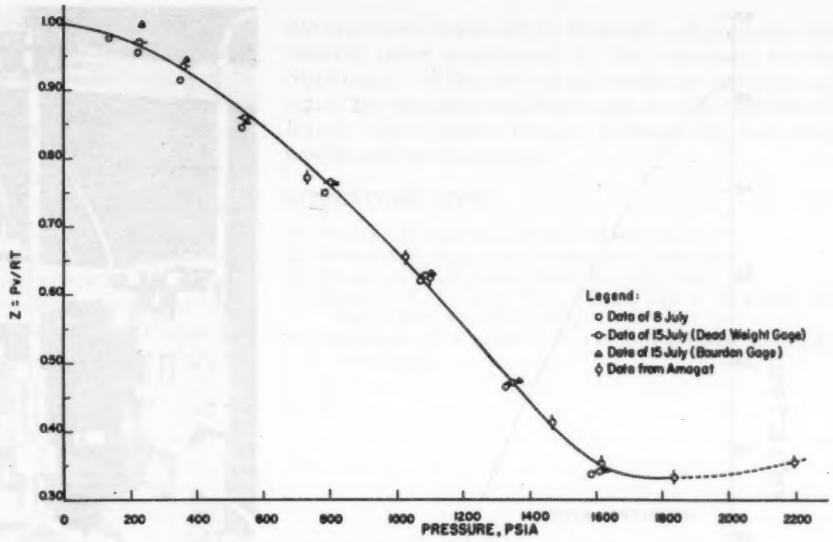

Figure 2. Compressibility Factors for Carbon Dioxide at 50.0°C.

CALCULATION

The method of calculation and treatment of data are summarized by the following equation and by Figures 3 and 4:

$$Z_i = KP(N)^{i-1}$$

where i is the state number, $K = Z_1/P_1$, and N is the volume ratio $((V + V')/V)$ of the expansion chambers.

The theory behind the method (*2*) is very interesting and can be conveniently covered in the drill period or its study assigned as a separate homework exercise.

The constant N is determined by a procedure identical with that followed in ordinary compressibility determinations. The only difference consists in the substitution of either hydrogen or helium as the fluid, instead of carbon dioxide, because of their linear compressibility factors. Since the value of the volume ratio is constant for the particular expansion bomb used it can be advantageously predetermined. The value of the volume ratio is determined from the intercept of a graphical extrapolation to zero pressure as shown in Figure 3.

The volume of the constant K is determined graphically from the experimental data. It is given by the reciprocal of the intercept at zero pressure of the plot of P_i versus $P_i N^{i-1}$ as shown in Figure 4.

APPARATUS

Figure 5 is a picture of the entire apparatus. Most of the parts were machined in the departmental shop. One may note that the only special pieces of equipment not readily available are the expansion chamber and the diaphragm.

A close-up of the expansion bomb may be seen in Figure 6. The bomb is constructed of 304 stainless steel with brass nipples. The bomb chambers are

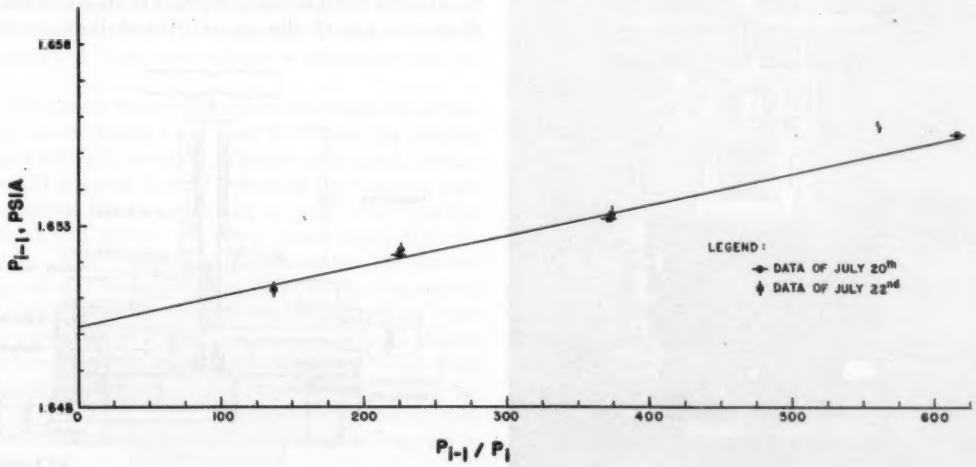

Figure 3

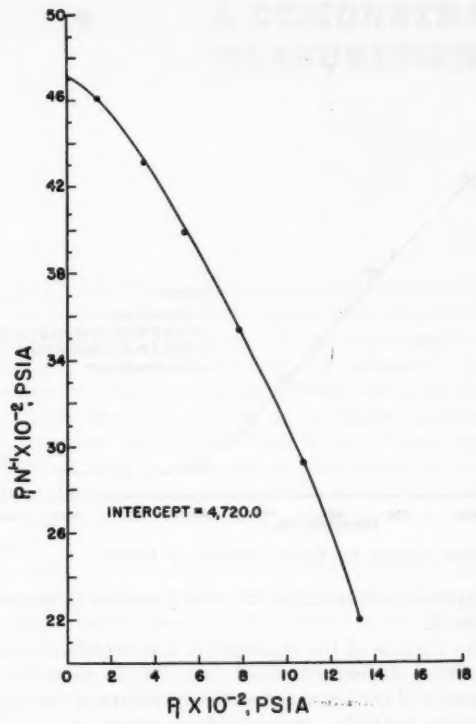

Figure 4

sealed by electrically welded plugs. The valves are modified Hoke 341 and 351, stainless-steel bodied. The modification consists of replacement of the standard

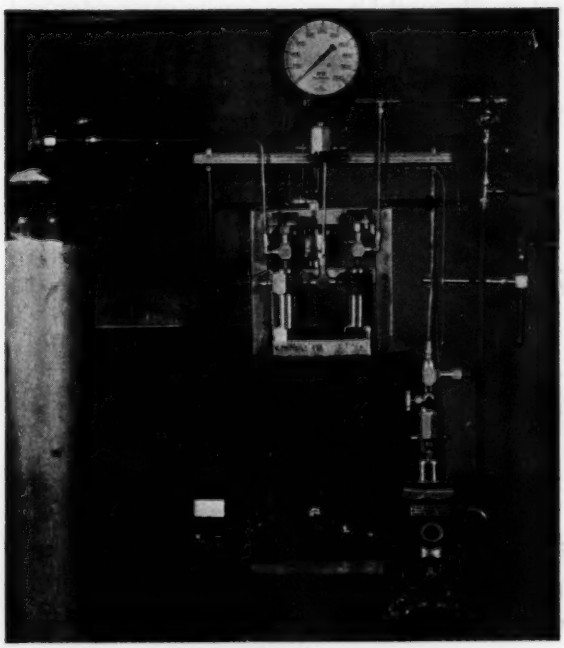

Figure 5

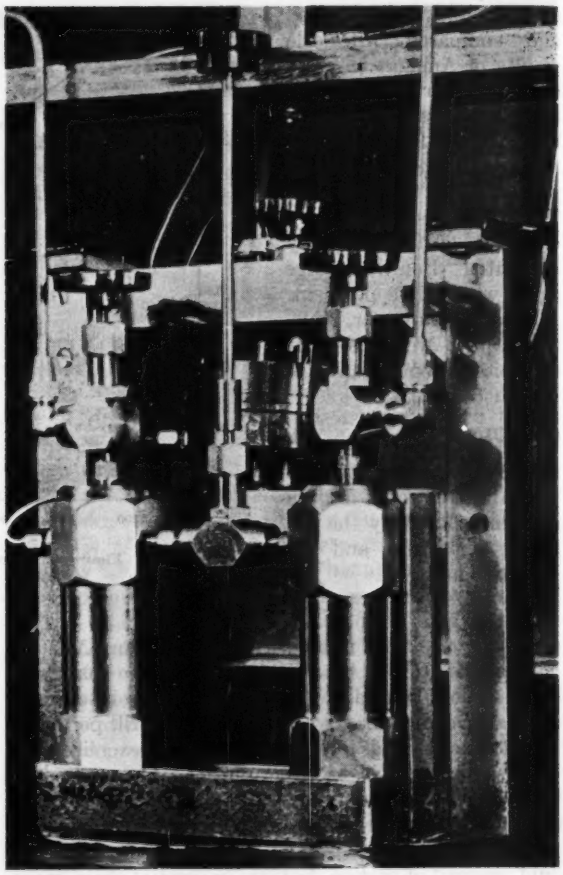

Figure 6

rubber packing with a stainless steel plug constructed in such a manner as to accommodate three Neoprene "O" rings. The bomb assembly weighs approximately 10 lb. and the total internal volume is about 50 ml. Both chambers are of the same internal bore, so that the

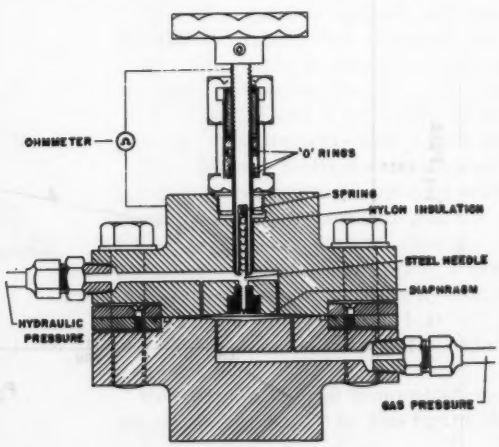

Figure 7. Diaphragm Cell

change in volume with pressure largely cancels out in the determination of the volume ratio N.

The diaphragm, which can also be observed in Figure 6, serves to separate the gas phase from the oil used for transmitting the pressure to the gage. A cross section of the diaphragm is shown in Figure 7. It is a modified version of the type developed by E. S. Burnett (*2*) and similar to the one described by Selleck, Carmichael, and Sage (*4*).

The diaphragm is constructed of cold-rolled steel and is case hardened. In place of the original contact-indicating mechanism, an electrically insulated valve body is inserted. This modification simplifies the adjustment of the contact needle. In operation, the gas pressure is balanced by hydraulic oil pressure, this balance being ascertained by the operation of the diaphragm. When the gas and hydraulic pressures are equal, the stainless steel diaphragm is at its midpoint of travel, which causes contact between the indicating needle and the diaphragm.

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WHAT THE TECHNICAL BOOK EDITOR EXPECTS OF AUTHORS[1]

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The word "editor," as we shall use it here, refers to the person whose responsibility it is to prepare for publication in book form the technical manuscripts submitted by the authors. He is the publisher's official representative in dealing with the author. For a harmonious operation and a happy result it is essential that both the editor and the author understand each other's point of view and exhibit a willingness to cooperate.

The editor must constantly remember that the author is usually an extremely busy man to whom the writing of books is often of secondary importance, and that he has devoted a great deal of valuable time and a vast fund of knowledge to preparing a book, the royalties from which will almost certainly never repay him for his efforts. The editor should not expect the author to do his job for him. On the other hand, the author should appreciate the importance of the editor's insistance on clarity and legibility, accuracy, and logical presentation, as well as his problems in dealing with the high costs that plague book production all along the line. The first thing, then, that the editor expects from the author is cooperation, evidenced by a willingness to accept changes suggested by the editor in a sincere effort to improve the over-all quality and appearance of the book. It must be said at once that most of the authors with whom this editor has dealt have intelligently fulfilled this obligation.

The editor is responsible for the technical accuracy of a manuscript only to the extent that he should catch any mistakes that a reasonably well-informed and observant student of the sciences could be expected to note. He is definitely responsible for the logical arrangement of the author's material, for the language in which it is expressed, and for the typographical correctness and appearance of the finished book. Though he usually has assistants to carry out details of production, he should set up the mechanical specifications, such as type selection, page size, handling of illustrations, captions, and other material.

But first of all he must deal with the manuscript. In some cases this comes to him either from an entirely unknown author, or from one who had already written the book before specifications for manuscript preparation could be given him. I might add here that point number 2 which the editor expects from the author is reasonably close adherence to the directions given him before he prepares his final manuscript. These cover such routine matters as typing, corrections, form for

[1] Presented as part of the symposium on "What Editors Expect of Authors and Why," at the 123rd Meeting of the American Chemical Society, Los Angeles, March, 1953.

literature references, illustration copy, indexing, and general appearance.

ACCURACY

Let us review the editor's duties in some detail, with the idea of showing how the author can reasonably be expected to help him produce a book of which both will be proud. First there is the matter of factual accuracy. It is human to be careless about details; on the other hand no editor has either the knowledge to pass on any large proportion of the author's facts or the time to investigate them. Most manuscripts are carefully checked for accuracy by referees before entering the publication mill. Yet there are many occasions in work prepared by thoroughly capable scientists where glaring inconsistencies crop up, where quoted matter is improperly treated, where outright errors in mathematics occur, and where chemical reactions do not balance. Most of these, of course, are caused by carelessness—certainly not by ignorance. Even so, if allowed to appear in the finished book, they give an appearance of intellectual shoddiness that undermines the reader's trust in the author's competence.

The matter of consistency is especially important, notwithstanding the classic dictum that it is a virtue of small minds. It is disconcerting to find a statement of fact in one chapter that is contradicted in a succeeding chapter. This usually means that the author modified his point of view or obtained new data, but forgot to introduce the change in every case. Indeed, perfect consistency of thought, facts, and especially of abbreviations, etc., is one of the editor's chief bugbears and is often almost impossible to obtain. Mistakes in mathematical equations and in the valence relationships in complicated organic formulas are among the most frequent and the hardest to catch. Usually the author will find them himself—after the type has been set or the engravings made. Usually, but not always!

I know of one case involving a book written by two highly competent research men, together with the head of the physics department of a well known university as senior author. The junior authors, not having a typewriter with Greek characters, typed in as much as possible of their equations, intending to insert the Greek symbols by hand later on. For some reason they had to do this in a hurry, with the result that many were omitted and the book was riddled with apparent errors (all duly pointed out by journal reviewers), much to the disgust of the senior author. Had the editor been an advanced mathematician, he might have caught this.

My point is that no editor can be expected to be sufficiently versed in the many fields of science covered by his house to detect errors which would be obvious only to the specialist. Moreover, he usually gives the author the benefit of the doubt, and assumes that matters relating to his field of investigation will be accurately treated. Point number 3, then, from editor to author: please be as consistent as possible and check all mathematical and chemical formulas carefully. If the author doesn't find the mistakes himself, book reviewers surely will!

ORGANIZATION

The editor also expects the author's work to be logically presented, well integrated, and coherent. Topical subdivisions of the chapters are a great aid in organizing a complicated subject. Even if these are not to be retained in the text as subheadings in boldface or italics, it is recommended that authors use them as guides in constructing their chapters. If this organizational job is not well done, it is the function of the editor to point out weaknesses in chapter structure, repetitious statements, and all other violations of chapter coherence that he finds. Observation of well established rules of rhetoric and expository writing is essential for any effective piece of technical writing. On the contrary, illogical presentation of facts, weak-kneed sentences, and a meandering style can be fatal to almost any book.

There are cases in which the author may be eminently qualified by practical experience to write a book about some industrial subject and yet be definitely incapable of the sort of organizational problem presented by a book-length presentation. In such instances, the editor can do one of two things: (1) hire a competent ghost writer, or function as one himself; (2) insist that the author find a collaborator, perhaps a young chemical engineer or research assistant with a natural flair for writing. In any case, it is the author's obligation and the editor's duty to provide the reader with a soundly constructed, well-integrated coverage of the subject indicated by the title. If this cannot be achieved in the ways suggested, the editor should reject the book. There are often exit clauses in publishing contracts covering such contingencies.

STYLE

Little need be said about literary style in this paper. One cannot expect scientists to write in Addisonian periods or even with any special degree of rhetorical accuracy. The most I believe the editor should expect is reasonably grammatical English, correct spelling and punctuation, and a proper sense of emphasis and economy in the use of words.

One of the most persistent minor faults in style is the lack of appreciation of the importance of emphasis. Sentences often end in a string of nearly meaningless phrases, the emphatic words being buried somewhere en route. This greatly weakens the points it is desired to make, especially in textbook writing. Here the editor can function very effectively by merely changing the author's word order. Such changes, as well as those of a grammatical nature, should be checked with the author before type is set to be sure that no inadvertent change of meaning has been introduced. Most authors are quite cooperative, and are even grateful for such improvements; indeed many of them definitely expect it as part of the publisher's service.

In general, good advice to authors, so far as style is

concerned, would be to keep sentences comparatively short; to be sure that pronouns refer to the correct antecedent; to include a verb in every sentence; and to avoid unclearly related clauses and phrases. Do not indulge in flights of fancy or questionable philosophy, which are out of place in a scientific book. Occasionally even the most conservative authors will be sufficiently carried away by their enthusiasm to make such comments as "To think that nature should have devised such a mechanism," or "We can have no doubt that such is nature's purpose." Remarks of this sort should be removed, with due regard for the author's feelings.

MANUSCRIPT FORMAT

Let us now devote some attention to the more mechanical aspects of manuscript preparation. In general, these are covered by the publisher's directions, as previously mentioned.

It is expected that manuscripts will be submitted as typewritten originals on standard white paper of good quality. Third and fourth carbon copies are not acceptable; yet they are occasionally supplied because the author for some reason prefers to file away the original—and never mind the eyesight of the editor and compositor!

Manuscript handwritten in either pen or pencil is not acceptable unless the writing is very clear and legible. Extensive deletions and phantom-like pencil tracings covered with erasures are sometimes submitted as finished copy. It is obvious that this sort of careless work imposes a heavy burden of time and expense on the publisher and can result only in galley proof that is full of errors. This is what printers refer to as "penalty copy"—meaning double charge. Costs for composition of moderately difficult technical material run from $6 to $7 a page; for chemical formula and mathematical copy from $9 to $12 a page; and for 8-point ruled tabular material up to $25 a page. The total composition cost of a 500-page technical book often may amount to as much as $8000. In view of these figures it behooves the author for his own sake, if not for the publisher's, to supply typewritten copy that is in reasonably finished form.

While we are on the subject of handwriting I once had an interesting comment from one of our authors. His manuscript involved considerable higher mathematics which he had written in ink. This would have been acceptable enough if his writing had been legible. Actually he had a very small, foreign-appearing hand, and in many cases the equations were crowded against the right-hand margin in such a way as to be indecipherable. When I mentioned this to the author with the comment that this condition was largely responsible for the delay in processing his manuscript, he replied that whether or not handwriting is legible is merely a matter of personal opinion.

Occasionally the editor is confronted with material typewritten in capitals and small capitals. Copy such as this is extremely difficult to read—especially after the first page or two. The initial capitals do not stand out, and the whole effect is to exhaust and exasperate the editor.

It might seem unnecessary to require that typed matter be double-spaced and written on white paper. Yet many authors still insist on crowding their copy together into closely packed paragraphs which make even the most routine style markings and corrections extremely difficult to make. This is likely to result in errors in composition and headaches for everybody.

The correct handling of literature references should be a simple matter, especially after specific instructions have been given. Yet one often wonders how many variations of style it is possible for the human mind to think up—it seems as if each author introduces a new and different one. If consistency is to prevail (and it is certainly most desirable), it is necessary for an editor or an assistant to work his way laboriously through hundreds of references. This is the kind of detailed job that cannot be delegated to the printer, since it should follow the style indicated by *Chemical Abstracts*. This, too, is the author's responsibility.

In the case of tables of data, the title and source should be clearly indicated. Column headings should be centered over the data to which they refer—not placed an inch or two to one side or turned endways. The use of boxheads and rules is recommended for complicated or double-entry tables. Footnotes and other explanatory matter should be referred to by use of numbers or letters rather than by a series of special characters, such as asterisks, daggers, and similar nightmares. I recall a recent book in which the manuscript called for as many as a dozen notes in a single table, each designated by a combination of symbols. In such cases, the word "nightmare" is no exaggeration! As far as illustrative material is concerned, the editor expects clearly drawn and legibly lettered diagrams and charts. The author should remember that his copy may have to be reduced in size by as much as 65 per cent; therefore he should make the lettering large enough to be readable after reduction. The figures should be drawn in ink on tracing paper or clean white paper and the letters done in clear block capitals. Copy for halftones should be furnished as glossy prints; pictures clipped from magazines and journals are usually not satisfactory.

The author should select his pictures for the purpose of making the meaning of the text clearer to the reader, rather than for artistic decoration. In most technical books illustrations of machinery and process details are useful; but pictures of freight cars, ships, miscellaneous end products, and the like are usually a needless expense. The test for inclusion of an illustration is, "Does it help to explain the subject matter?" If it does not, it should be omitted.

PROOFREADING

The foregoing is a brief review of the most important points for the author to have in mind in preparing the manuscript for the publisher. However, his duties do not end here by any means. There remain such oner-

ous chores as proofreading and index-making. These are often turned over to laboratory assistants or to personal secretaries. The latter are invariably enthusiastic perfectionists who seem to feel that having at last got a blue pencil in their hand, they are going to use it with all possible vigor. I have seen the galley proof of many a well written and carefully edited manuscript come back with punctuation arbitrarily altered, sentences rewritten, and the minutest details duly marked, almost as if the reader enjoyed making as many corrections as possible. Too much of this sort of thing can completely dispel any lingering possibility of keeping the selling price down.

For this reason most houses rule that any expense for alterations in excess of 10 per cent of the cost of original composition must be borne by the author. It is interesting to note how meticulous some authors are about punctuation at the proofing stage of the book, and how quick they are to cease to be so when reminded of this rule! The allowance of 10 per cent of composition cost is usually ample to permit legitimate additions and corrections. It must be remembered that printers charge a far higher rate for correction than for setting type in the first place, because of the time-consuming nature of the work. The chief point to keep in mind is that removal of letters from a line should, if possible, be compensated by an equivalent addition in the same or the following line. The nearer the change is to the start of a paragraph the more important this rule becomes, and vice versa.

For example, if the word "therefore" is removed from the first line of a long paragraph, the entire paragraph has to be reset, as all the following lines are thrown out of adjustment. It is often possible to replace such deletions with words that are as nearly meaningless as possible, such as "indeed" or "in general." Training in crossword puzzle techniques is helpful in this connection.

Sometimes authors forget that type compositors are not chemists or mathematicians. I recall several actual cases in which instructions such as the following were penciled on the margin of the proof: "Printer: please rotate this illustration counterclockwise through 90°"; also "Printer: suggest that you integrate this equation." Needless to say, such instructions would be meaningless to the corrector. In spite of this, some authors contend that technical compositors should be trained scientists. This point of view is thoroughly naïve. Simple, specific instructions are always best, on the theory that the less thinking the compositor has to do, the better the results will be.

INDEXING

The final responsibility of the author is the preparation of indexes for his book. These usually include a name index and a subject index; sometimes there are also patent and trade-mark indexes. Of these the only one that gives any trouble—and by far the most important—is the subject index. Detailed instructions on index making would be out of place here. Anyone interested can get an excellent idea of this occult art by referring to the sixth chapter of Crane and Patterson's "Literature of Chemistry." Being human, the author will want to delegate to an assistant the time-consuming and tedious task of making three or four thousand index entries on cards, then sorting, combining, and alphabetizing them. The point to be emphasized is this: though the technique is largely mechanical, a thorough background in the subject is required. Hence it is not wise to assign the entire job to anyone who does not know his way around in it pretty well. Some authors index too thoroughly, with the result that by the time they finish they have virtually rewritten the book. Others make such a scanty index that it is almost useless. A governing rule is that an index should be of such length and detail as to fulfill its function of helping the reader locate quickly the information contained in the book. It should not give any information about the subject referred to other than the pages on which it is discussed. It should be adequately cross-referenced, and general headings should be subdivided as much as necessary for quick use.

Some common faults of over-indexing are: (1) listing every noun in the book; (2) indexing adjectives instead of nouns; (3) listing every entry under one heading. The last of these is especially to be avoided. For example, in a book on sugar it would be perfectly possible to refer every statement to the entry "sugar." Obviously this would be poor indexing, for it doesn't help the reader in the least. In like manner one should refrain from using chapter titles and subtitles as index entries, as these are already supplied by the table of contents. An index should strike somewhat below the level of major text subdivisions, yet remain above the level of words and phrases, except in special cases like names of chemical compounds. There is also the other extreme of under-indexing, where the author covers ten pages of discussion with a single entry. I recall an index in which a scholarly treatment of the thermodynamics of temperature scales covering a dozen or more pages of small type was considered to be adequately indexed by the entry "temperature, pages 100–115."

Good index-making is an art, and as most authors are not confronted with the problem more than once or twice in their lives, they can hardly be expected to do a perfect job. Editors and their assistants are usually ready to help and almost always have to do considerable touching up.

To summarize, there are five things that the editor expects from the author: (1) general cooperation on the whole project, with the aim of producing a fine book; (2) willingness to follow directions supplied him governing details of manuscript preparation; (3) attention to accuracy and consistency, even down to small details; (4) logical organization of subject matter, usually best obtained by use of a topical outline of chapters; (5) finally, good English, including punctuation and spelling. By observing these conditions the author can avoid producing what one of my editor friends once called a "type-rotten" manuscript.

TWO EXPERIMENTS IN SPECTROPHOTOMETRY

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One of the difficulties in teaching instrumental analysis is the emphasis necessarily placed on operational details. Generally only the simplest processes are investigated instrumentally in order to avoid complicating the task of making the instrument work. The result may be that the student knows how the instrument works, but has only a vague idea of the kinds of chemical investigation that are best performed with it. This is particularly true of ultraviolet and visible spectrophotometry where the determination of the absorption spectrum of some colored compound or an indicator constant appears to be a favorite experiment. The student is left with the limited notion that one can determine absorption spectra and do simple colorimetric analyses with a spectrophotometer; the more interesting determinations of molecular weights, formulas of soluble colored complexes, ionization constants of colorless acids and bases (in the ultraviolet), other equilibrium constants of many varieties, steric effects, and similar topics of structural organic chemistry[1] may be overlooked.

To demonstrate the versatility of a spectrophotometer more suitably the following experiments, requiring not more than three hours working time, have been in use here for several years. Although the procedures are written for the ionization constant of benzoic acid and the formula of the complex between chromate and hydrogen ions, other aromatic acids, phenols and polyfunctional acids may be substituted in the first experiment and other complex-forming pairs in the second. The Beckman DU Spectrophotometer, for which separate operating instructions are provided, is used.

Ionization Constants of Weak Acids. The ionization constant of a weak acid can be obtained if there is a significant difference at any wave length between the absorbancies of the free acid and the acid anion. If the absorbancies of the compound in acid solution, basic solution, and a buffer such that the acid is partially in the anion form are determined at a suitable wave length, the ionization constant, K_c, is given by

$$pK_c = pH + \log \frac{b - e}{e - a}$$

where the pH is that of the buffer solution of the acid having absorbancy e, and a and b are the absorbancies of the same concentration of acid in 0.1 N hydrochloric acid and 0.1 N sodium hydroxide respectively.

Procedure. Ten-ml. portions of a saturated solution of benzoic acid are pipetted into three 25-ml. volumetric flasks. One solution is diluted to the mark with 0.2 N hydrochloric acid, one with 0.2 N sodium hydroxide, and the third with 0.2 N acetate buffer (pH 4.7, composed of equimolar amounts of acetic acid and sodium acetate).

Measure the absorbancies of the solutions at 286, 288, and 290 mμ. Record the temperature of the solutions. Calculate values at each wave length for the ionization constant and compare with values at this temperature in the literature.

Better results may be obtained if additional buffer solutions in the pH range 4 to 6 are measured, and the calculation made graphically from a plot of absorbancy against pH.

The thermodynamic constant, K_a, may be calculated with the following equation

$$\log K_a = \log K_c - \frac{I^{1/2}}{1 + I^{1/2}}$$

where I is the ionic strength of the solutions.

Complex Formula Determination by the Method of Continuous Variations.[2] If two equimolar solutions of substances that form a soluble colored complex are mixed in varying ratios, that ratio which corresponds to the mole ratio of the components in the complex will have a maximum (sometimes a minimum) absorbancy at a suitable wave length. If either component is colored, the absorbancy must be corrected for the contribution to the color from this component. By plotting the difference between the measured absorbancy and the absorbancy calculated for no interaction against mole per cent (or its equivalent) of either component the complex formula is readily obtained.

Procedure for Chromate-Acid Reaction. Prepare 0.1 M solutions of potassium chromate and hydrochloric acid. Using graduated 10-ml. pipets and 25-ml. volumetric flasks make up the following nine solutions: 10 ml. chromate; 9 ml. chromate, 1 ml. acid; 8 ml. chromate, 2 ml. acid; etc. It will not be necessary to prepare the solution containing 10 ml. acid since it may safely be assumed that its absorbancy in the visible region is negligible. Dilute all solutions to the mark and mix.

Measure the absorbancies of all solutions at 470, 505, and 525 mμ. Correct the absorbancies of the mixtures by subtracting from each the contribution expected from the amount of chromate present. Plot these corrected absorbancies (Y values) against volume of chromate at each wave length.

What is the formula of the complex between chromate and hydrogen ion as indicated by these data? Consult the literature[2] for an explanation.

[1] Ferguson, L. N., "Electron Structures of Organic Molecules," Prentice-Hall, Inc., New York, 1952, p. 292.

[2] Vosburgh, W. C., and G. R. Cooper, *J. Am. Chem. Soc.*, **63**, 437 (1941).

LET'S USE PROBLEMS TO TEACH CHEMISTRY

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AN EXAMINATION of the 25-year Cumulative Index to THIS JOURNAL reveals a number of contributions dealing with the solution of problems used in general chemistry. The authors of most of these articles emphasize the need for sound reasoning on the part of students solving problems; yet this emphasis is missing from many of the modern textbooks as well as from the separate books on chemical arithmetic itself. The presentation in these books convinces one that the emphasis is more on correct numerical answers than on the teaching of chemical principles. Thus, in the preface of one of the books now being advertised widely, the author states his opinion that simple proportion is the best approach for the beginning student and then uses that method wherever applicable. With little practice, a student who understands little chemistry can arrive at a correct numerical answer to a problem that lends itself to a simple ratio approach. But the final answers to most of these problems are incidental. Examinations from several colleges illustrate this point when the student is asked to give "a set-up that will allow one to calculate a correct answer; you need not perform the arithmetic."

FORMULA APPROACH

Texts often give a mathematical formula to fit each type of problem. Thus in the chapter on gases we find

$$\frac{PV}{T} = \frac{P'V'}{T'}$$

a neat little formula that will permit anyone who can recognize which pressure, volume, and temperature are given first to solve for an unknown after a change has taken place, whether he has ever heard of the laws governing the behavior of gases or not. A formula relating density, pressure, and temperature is slightly different and to the student may appear unrelated or perhaps confusing.

Another formula,

$$\text{Mol. wt.} = \frac{1.86}{\Delta t} \times \frac{\text{g. solute}}{\text{g. water}} \times 1000$$

will permit one to compute the molecular weight of a non-electrolyte in solution. The errors attending the transposition of this formula to allow one to calculate, for example, the freezing-point lowering are well known to teachers of general chemistry. Other formulas for other types of problems are available. Note, however, that a different formula must be memorized for each type of problem, and even then there is no assurance that the student has learned the fundamental chemical principles. It must be admitted that the poorer, unthinking student can perhaps obtain correct numerical answers more often by the formula approach than by any other method. But these answers are not what we seek.

REASONING APPROACH

Our concern then is with a simple, consistent approach to problems that will emphasize above all a knowledge and understanding of the chemical principles involved. Several illustrative examples follow. An attempt has been made to give the reasoning process that might be used by a student in the course. We know that many departments of chemistry use similar methods and that these methods have been outlined by previous authors for one type of problem or another. A variety of types are included here to emphasize the versatility of the method. A single approach—one of reasoning from fundamental principles or definitions—suffices for all problems used in first-year college chemistry.

Calculation of Simplest Formula

(1) From experimental data: *Problem:* When 1.025 g. of copper was heated with sulfur in a crucible, the product of the reaction was found to weigh 1.283 g. What is the simplest formula for the copper sulfide formed?

Solution: The difference in weight between the product and the copper is the weight of the sulfur in the sample. Therefore 1.025 g. of copper has combined with 0.258 g. of sulfur and

$$\frac{1.025 \text{ g. Cu}}{0.258 \text{ g. S}} = \text{the number of grams of Cu combining with 1 g. of S}$$

Multiplying this fraction by 32 g. S/g. at. wt. S gives the grams of copper combining with 1 gram atomic weight of sulfur, *i. e.*,

$$\frac{1.025 \text{ g. Cu}}{0.258 \text{ g. S}} \times \frac{32 \text{ g. S}}{1 \text{ g. at. wt. S}} = \text{grams of copper per gram atomic weight of sulfur}$$

Finally, dividing by the grams of copper in 1 gram atomic weight of copper gives the number of gram atomic weights of copper combining with 1 gram atomic weight of sulfur, or the atoms of copper per atom of sulfur. The complete set-up and solution is

$$\frac{1.025 \text{ g. Cu}}{0.258 \text{ g. S}} \times \frac{32 \text{ g. S}}{1 \text{ g. at. wt. S}} \times \frac{1 \text{ g. at. wt. Cu}}{63.54 \text{ g. Cu}} = \frac{2 \text{ g. at. wt. Cu}}{1 \text{ g. at. wt. S}} \text{ or } \frac{2 \text{ atoms Cu}}{1 \text{ atom S}}$$

and the formula is therefore Cu_2S.

(2) From percentage composition: *Problem:* A

[1] Present address: Louisiana State University, Baton Rouge, Louisiana.

certain compound is found to be composed of 32.45 per cent sodium, 22.55 per cent sulfur, and 45.10 per cent oxygen. What is the simplest formula of the substance?

Solution: To find the simplest formula, one must ascertain the relative ratios of atoms in the compound. Percentage ratios are numerically the same as weight ratios and these weight ratios may be used to calculate the number of atoms of one element which are combined with any other element in the compound. Thus, arbitrarily choosing sulfur as the basis for calculation (either sodium or oxygen may be used similarly with equal success) and following the same step-wise reasoning outlined in (1) above, we make the following calculation:

$$\frac{32.45 \text{ g. Na}}{22.55 \text{ g. S}} \times \frac{32.06 \text{ g. S}}{1 \text{ g. at. wt. S}} \times \frac{1 \text{ g. at. wt. Na}}{23.00 \text{ g. Na}} = \frac{2 \text{ g. at. wt. Na}}{1 \text{ g. at. wt. S}} \text{ or } \frac{2 \text{ atoms Na}}{1 \text{ atom S}}$$

and

$$\frac{45.10 \text{ g. O}}{22.55 \text{ g. S}} \times \frac{32.06 \text{ g. S}}{1 \text{ g. at wt. S}} \times \frac{1 \text{ g. at. wt. O}}{16.00 \text{ g. O}} = \frac{4 \text{ g. at. wt. O}}{1 \text{ g. at. wt. S}} \text{ or } \frac{4 \text{ atoms O}}{1 \text{ atom S}}$$

Thus, for every one atom of sulfur in the compound there are two atoms of sodium and four atoms of oxygen; the simplest formula is Na_2SO_4.

If oxygen had been chosen as the basis for the calculation, the results would have been

$$\frac{1/2 \text{ atom Na}}{1 \text{ atom O}} \text{ and } \frac{1/4 \text{ atom S}}{1 \text{ atom O}}$$

giving a formula of $Na_{1/2}S_{1/4}O$ or, to use only whole atoms, Na_2SO_4.

This approach seems to be more understandable to the student than the conventional one of dividing the weights of each element by the appropriate gram atomic weight and then manipulating the quotients into whole number ratios.

Gas Laws. Because problems of this type have been treated extensively by other authors, a single example, included for completeness here, should be sufficient.

Problem: When the temperature of a certain quantity of gas is 20°C. and the pressure is 750 mm., the volume is 2.0 liters. What must the pressure of the gas be if the volume is changed to 2.2 liters and the temperature to 30°C.?

Solution: The temperatures must be changed to degrees absolute. An expression that will permit a correct solution is

$$P = 750 \text{ mm.} \times \text{temperature factor} \times \text{volume factor}$$

where the temperature and volume factors are set up by reasoning from the perfect gas laws (or common sense). The temperature is increasing (293 to 303° A.). Therefore, other factors remaining constant, the pressure must increase and the correct temperature factor is greater than one or 303°A./293 °A. The volume is also increasing but this results in a decrease in pressure; the volume factor is therefore less than one or 2.0 l./2.2 l. The final expression then is

$$P = 750 \text{ mm.} \times \frac{303 \text{°A.}}{293 \text{°A.}} \times \frac{2.0 \text{ l.}}{2.2 \text{ l.}} = 705 \text{ mm.}$$

Volumetric Titration: Problem: How many grams of sodium hydroxide are contained in 25.00 ml. of a solution if 23.00 ml. of a 0.103 *N* sulfuric acid solution is required for titration?

Solution: Normality means *gram equivalent weights per liter.* Therefore a 0.103 *N* solution of sulfuric acid contains

$$\frac{0.103 \text{ g. eq. wt. } H_2SO_4}{1 \text{ l. } H_2SO_4}$$

Multiplying this factor by 0.023 l. of H_2SO_4 gives the number of gram equivalent weights of H_2SO_4 used, *i. e.*,

$$\frac{0.103 \text{ g. eq. wt. } H_2SO_4}{1 \text{ l. } H_2SO_4} \times 0.023 \text{ l. } H_2SO_4 = \text{number of g. eq. wt. } H_2SO_4 \text{ used}$$

This number is equal to the number of gram equivalent weights of NaOH used because 1 gram equivalent weight of any acid will neutralize 1 gram equivalent weight of any base. Finally, multiplying the number of gram equivalent weights of NaOH by the number of grams of NaOH in 1 gram equivalent weight of NaOH gives the number of grams of NaOH in the original solution—the answer to the question asked in the problem. The complete setup and solution then is

$$\frac{0.103 \text{ g. eq. wt. } H_2SO_4}{1 \text{ l. } H_2SO_4} \times 0.023 \text{ l. } H_2SO_4 \times \frac{1 \text{ g. eq. wt. NaOH}}{1 \text{ g. eq. wt. } H_2SO_4} \times \frac{40.00 \text{ g. NaOH}}{1 \text{ g. eq. wt. NaOH}} = 0.0947 \text{ g. NaOH}$$

Interpretation of Equations: Problem: Oxygen is produced by the decomposition of $KClO_3$ according to the equation

$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$$

What weight of oxygen can be collected by the complete decomposition of 3.017 grams of $KClO_3$?

Solution: The equation means that 3 mols of oxygen are produced from 2 mols of $KClO_3$. Only a fraction of a mol of $KClO_3$ has been used, however. To find the number of mols of $KClO_3$ which were used, one can multiply the number of grams of $KClO_3$ used by the number of mols per gram of $KClO_3$, *i. e.*,

$$3.017 \text{ g. } KClO_3 \times \frac{1 \text{ mol } KClO_3}{122.6 \text{ g. } KClO_3} = \text{number of mols of } KClO_3 \text{ used}$$

Since 3 mols of oxygen are produced from 2 mols of $KClO_3$, multiplying the number of mols of $KClO_3$ used by 3 mols O_2/2 mols $KClO_3$ gives the number of mols of oxygen produced:

$$3.017 \text{ g. } KClO_3 \times \frac{1 \text{ mol } KClO_3}{122.6 \text{ g. } KClO_3} \times \frac{3 \text{ mols } O_2}{2 \text{ mols } KClO_3} = \text{number of mols } O_2 \text{ formed}$$

The number of grams of oxygen formed is obtained by

multiplying the number of mols of oxygen formed by the number of grams of oxygen in one mol.

$$3.017 \text{ g. } KClO_3 \times \frac{1 \text{ mol } KClO_3}{122.6 \text{ g. } KClO_3} \times \frac{3 \text{ mols } O_2}{2 \text{ mols } KClO_3} \times \frac{32 \text{ g. } O_2}{1 \text{ mol } O_2} = 1.180 \text{ g. } O_2 \text{ formed}$$

DISCUSSION

The single objection to this method raised by chemistry teachers of the author's acquaintance is that the poorer student has difficulty reasoning through the steps, *i. e.*, the poorer student does not understand the chemistry. In order to prevent a serious morale problem, resulting from a large proportion of the class failing the course because of failure to be able to solve problems, it has been suggested that an "easier" method be taught. However, this author suggests that the same difficulty can be met, if necessary, by placing less emphasis on problems as such. That is, agility with numerical problems will not be considered a prerequisite for satisfactory completion of the course.

Several types of problems used in general chemistry are illustrated above. One can readily extend the method to other types. Reasoning and understanding are emphasized always. A student must know the meanings of words and clearly perceive the chemical relationships between terms. Although the method in some cases may not give the numerical answer as quickly as other methods avoiding this emphasis, the student experiences no difficulty in going from one type of problem to another. In every solution setup, the unknown quantity is set equal to something; there are no transpositions necessary. Slide-rule computations are simplified and the inclusion of units allows the student to make a quick check on the accuracy of his setup. In examinations where solution of the arithmetic will be too time-consuming, the instructor can quickly learn as much, or more, about the student's knowledge of chemistry by examining a setup of this type as by looking for a numerical answer.

Whenever we use problems in general chemistry, let us use them to teach chemistry—not just arithmetic.

A TAPER-TUBE CONDENSER

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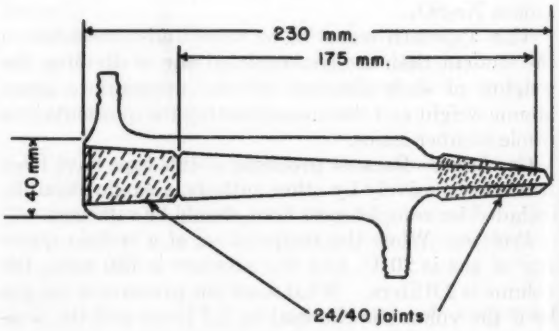
Sterling-Winthrop Research Institute, Rensselaer, New York

THERE is often a need for a small efficient Liebig type condenser in the synthetic laboratory. Current designs using standard taper joints, either full or partially jacketed, have not proved satisfactory because of hold-backs and general inefficiency. Particularly in high vacuum distillations where the use of wide bore heads, columns, etc., with 24/40 joints is most imperative, the bulbous reservoirs fore and aft of the joints present serious physical difficulties.

In an attempt to improve the drainage and increase the efficiency of a small condenser, the authors have designed and built the described unit. The full-jacket construction coupled with the tapered inner tube gives outstanding efficiency with low-boiling liquids. The female joint is attached to the inner tube without the customary bulb, allowing constant complete drainage during distillation. Experimentation with various lengths in our laboratory has shown that the size



indicated is quite adequate for good efficiency in most of the ordinary distillations.

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THE EVALUATION OF WETTING AGENTS

A Student Experiment

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THE official method of the American Association of Textile Chemists & Colorists for the comparison of wetting agents consists in finding the concentration of wetting agent required to cause the sinking of a 5-g. skein of standard two-ply cotton yarn in a standard time. The skein, carrying a hook of standard weight (3 g.), is held beneath the surface of the wetting solution by a 20-mm. thread attached to a heavier weight (40 g.) called the anchor. The concentration to cause sinking in a standard time of 25 seconds is obtained from a curve plotted from average sinking time for a range of concentrations. It is called the Draves index.[1, 2, 3]

The following experiment based on the Draves method has been found to give surprisingly good results in the colloid laboratory. Students have consistently obtained the same order of wetting for a series of commercial detergents and surface-active compounds as was previously obtained using the official method.

Figure 1

The experiment described below employs undyed pipe cleaners, which cost little.

The sinker consists of a 1.5-cm. piece of heavy capillary tubing through which is a triangular loop of Constantan or other wire. To the wire is attached a loop of linen thread 15 mm. long. The cylinders used are the tallest 100-ml. ones selected from stock. These give ample coverage of the immersed pipe cleaner.

The experiment requires much lower concentrations and much smaller volumes of wetting agent than the official test. Stock solutions containing 2 g./l. can therefore be used conveniently.

PROCEDURE

Prepare 250 ml. of standard solutions of the assigned detergents or wetting agents, either by dilution of stock solution or by direct weighing, to contain 1.00 g./l.

Pour gently 100 ml. of prepared solution into a graduated cylinder and allow to stand until all bubbles have come to the surface. Record the temperature of the solution.

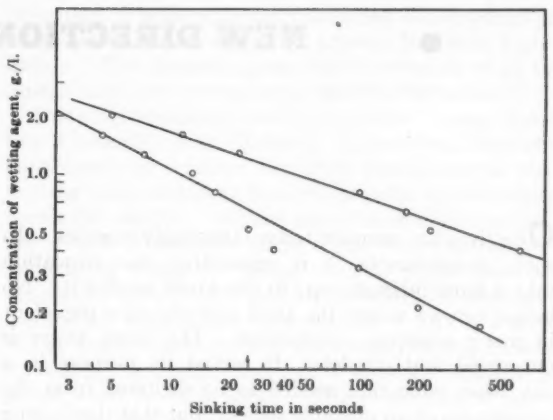

Figure 2

Bend the end of a pipe cleaner so as to make a hook as shown in Figure 1. Pass the bend through the thread loop attached to the sinker. The pipe cleaner is then held by the tip with the anchor and thread immersed. Start the stop watch the instant the pipe cleaner is immersed. The pipe cleaner will now be floating vertically with the thread taut and bubbles of air escaping from the tip. Stop the watch the instant the pipe cleaner hits the sinker. The latter time is indicated instead of the first slackening of the thread in the Draves test, because it has been found that with low concentrations (*i. e.*, long wetting time) the escape of the second-last bubble causes a downward push by the displacing solution, and the buoyancy is such that the pipe cleaner neither sinks nor rises but the anchor line is slack. Handle the pipe cleaners as little as possible.

Determine sinking times in triplicate or until consistent values are obtained. Discard any determinations giving values under two seconds and proceed to next dilution. Repeat, using concentrations of 0.75, 0.60, 0.45, 0.15, 0.10 g./l. or other appropriate dilutions to give a range of times between approximately 2 and 300 seconds. Solutions for successive tests may be prepared by pouring off the required amount from the preceding test and diluting: 75 ml. of No. 1 made up to 100 gives No. 2; 80 ml. of No. 2 gives No. 3, etc.

Solutions containing 0.30 g./l. or less should be prepared by proper dilution of the stock solution. Place the used pipe cleaners on a clean laboratory towel. Plot on log-log paper average sinking time versus concentra-

[1] "Year Book of the American Association of Textile Chemists and Colorists," 1942, p. 248.

[2] DRAVES, C. Z., AND R. G. CLARKSON, *Am. Dyestuff Reptr.*, 23, 1938 (1934).

[3] YOUNG, C. B. F., AND K. N. COONS, "Surface Active Agents," Chemical Publishing Co., Inc., Brooklyn, New York, 1945, p. 85.

tion. Repeat the test for any concentration which is obviously in error. Determine the concentration corresponding to 25 seconds sinking time for each of the assigned detergents.

Figure 2 shows typical student results for two different detergents.

The pipe cleaners when dry are used again by the class in semimicro qualitative analysis.

NEW DIRECTIONS FOR EDUCATION[1]

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OUR lives are complex today, amazingly complex. In such circumstances, it is imperative that education take a more intimate part in the world around it. No longer can we accept the aloof attitude once prevalent in many academic institutions. The ivory tower is outmoded and obsolete. It served its purpose in a day when education needed to be sheltered from the vicissitudes of an unstable society, but that day is long gone in most of the world.

The fruits of the tremendous intellectual capacity present in our universities should no longer be limited to the classroom. They should be made available to society, for society's need for them is very great. More than that, many of society's problems stem from events that originated in the university laboratory. It is reasonable to expect these same talents and facilities to participate in their solution. Education, then, must broaden its area of influence. Not only through choice, but also through need and duty, it must concern itself with world affairs. We used to teach geography and chemistry, physics and economics as separate and distinct disciplines. But now, when Soviet Russia explodes a hydrogen bomb the explosion influences us, thousands of miles away from the explosion. So geography and technology now seem very close together. Educators can no longer ignore one and be competent in the other. By extension, we could say the same about all the other subjects we teach.

Modern communication facilities are other factors removing the barriers that separated different parts of the world. Yesterday's far-off land is today's neighboring community. Yesterday's long and arduous journeys are now accomplished quickly and easily. This new perspective with which we view the world has little to do with the usual political concepts of internationalism or isolation. We are concerned primarily because of our own self-interest. We realize that without the raw materials and trade outlets of other nations our superior standard of living would not exist. We recognize that events in other parts of the world, to a large degree, determine the conduct of our own affairs. The composition of our huge national budget is the most obvious example; more than three-quarters of it is directly influenced by the international situation. Relatively, today's domestic issues govern the nation's economy to a lesser degree than they did in the past.

These are the circumstances that exist. To be effective as well as realistic, education must adjust itself to them. Unless it does so with considerable success, it will be unable to play the continually expanding role that society is demanding of it. Certain obligations are abundantly clear. Technological institutions must supply competent graduates to reduce the critical shortage of scientific and engineering personnel now existing and expected to continue in this decade. They must also participate in improving national productivity, for this represents the principal solution to problems that will be precipitated by the country's tremendous increase in population in the remainder of this century. Estimates reported to be conservative predict an enlargement of our population to the extent of at least 50 million more persons by the year 2000 A.D. Serving more than 200 million people will demand the vast expansion of everything in the United States.

Along with this, if present trends continue, will go a reduction in the length of the work week. In all probability a work week of 30 hours or less will materialize well before the end of the century. Thus we are faced with the problem of satisfying the demands of an expanding economy for a greater flow of goods at the same time that the people producing the goods are working fewer hours. This poses a neat problem, and the only solution is to improve productivity, to increase output per man-hour. In such an undertaking, technological educational institutions must play a major part. Only an advancing technology can accomplish the miracle required and give men more goods with less work.

[1] Presented at a meeting of the Division of Chemical Education, American Chemical Society, Chicago, September 9, 1953. Dr. Rettaliata is president of the Illinois Institute of Technology.

In the chemical industries, for example, we will need plants more modern and more self-sufficient than today's newest structures. I am confident that we will have them, these production miracles with processing operations monitored and controlled by automatic units capable of adjusting for variables without disrupting production. Even now, new planning methods emerging from scientific laboratories, such as servomechanism techniques, hold promise of markedly increasing efficiency and output of tomorrow's chemical plant. I am told that evolution of technology in the chemical industry already has increased the value of an individual worker's annual output from $15,000 in 1939 to some $26,000 today. On an industry-wide basis, introduction of continuous processing methods and broader application of automatic control devices have resulted in today's physical volume's being three times what it was 15 years ago. I do not expect the workerless factory of the science-fiction novels. These technological advances we are witnessing will *contribute* to the worker's productivity, not replace him.

Although factories are becoming automatic, the advances in knowledge that are required before they can be built are *not* automatic. They must be developed painstakingly, often in the laboratories of educational institutions and imparted to students in those institutions. Here, I believe, the private educational institution fills a real need. The strength of the private college is in its independence, and its value lies in its diversity. It can do, and is doing, many unique and needed jobs in education. This type of education must be preserved, yet it is approaching a perilous state.

FINANCES

A recent survey conducted by the *New York Times* emphasizes the financial dilemma of most private educational institutions. The survey of 810 institutions of higher learning revealed that almost one-half of the private ones are unable to balance their budgets. It is no exaggeration to say that the future existence of some of these institutions is seriously threatened. For all of them, survival demands that the gap between income and expenditure be diminished or eliminated. How can this be accomplished?

The solution that comes first to mind is to reduce expenses. All institutions, I am sure, have explored this approach until further curtailments would endanger their academic programs. Another consideration is to increase tuition, and this too has been done by practically all institutions over the past decade. But tuitions at private institutions are now about as high as they can be without having the undemocratic effect of depriving some deserving students of this type of education.

The only method remaining that seems feasible for solving the grave problem is to obtain additional income through contributions. Under our present tax structure, the wealthy individual is rapidly becoming extinct, so the source of future contributions must necessarily be limited essentially to alumni, foundations, and corporations. Of these, corporations possess the greatest potential.

Corporate management deserves commendation for its increasingly enlightened attitude toward support of private education. It is increasingly clear to company officials that business is benefited by strong educational institutions. They see how colleges and universities, besides developing the intellectual and cultural potentialities of man, have strengthened the national economy by improving existing methods of doing things and creating entirely new markets. A good illustration, I believe, is the pioneering development of magnetic sound recording by Armour Research Foundation. This pioneering resulted in creation of an industry that now grosses about $50,000,000 annually.

This single example could be multiplied many times. Our Chemistry and Chemical Engineering Research department at Armour Research Foundation is conducting many different research projects for industries across the country. Almost any of them might conceivably result in a new industry or the vast expansion of an existing industry. These projects range from development of a better denture adhesive to finding a method for continuous vulcanization of rubber stocks. We at Armour have worked out a rapid drying method for paint, varnishes, and other coatings applied to metal, wood, cloth, or paper. This process might prove to be of particular value to furniture manufacturers because it could reduce drastically the extended time and large floor area now required in their drying operations.

Other men and women in the department are studying catalyst de-activation. Still others are investigating the role of lubricating oil in production of combustion-chamber deposits in automotive engines. The study has led to advances in our understanding of how motor oils undergo oxidation. Our chemists and chemical engineers are also performing public service duties for the city of Chicago and for every person who lives or works here. They are giving technical assistance to the City Council Committee on Building and Zoning by studying problems connected with smoke and fly-ash emission, noxious gases, dust and dirt, noise abatement, and industrial odors.

Illinois Tech, like other institutions, is training the men and women who will man the development laboratories and executive offices of industry in the near future. It is inspiring work, and the results are invariably gratifying. We believe that we are serving business and industry well, and we believe our sister institutions are doing so too. But we know, and we know it well, that we cannot continue to do so without additional support. If that support is not forthcoming in sufficient strength from private sources, it would be logical for federal subsidy to enter the picture. We would not welcome that turn of events, but it would come anyway, for the educational job would have to be done and the facilities of the private institutions would be the only ones available for the purpose. Present tax-supported institutions would not have the capacity to take on the additional load themselves, for private colleges

and universities now enroll about half the total college population.

The pattern in such a case could well be the one we have observed in other countries where government has taken over all the educational facilities. Even when begun with the best of intentions, the result all too frequently has been intellectual control, followed by tyranny. I do not want that. I firmly believe that perpetuation of our system of private education lends assurance to the retention of our priceless heritage, freedom. Private education and freedom are inseparable. Each mutually strengthens and safeguards the other. So I believe it is reasonable to expect increasing financial support from business and industry. Their interests as well as ours demand it.

ACADEMIC FREEDOM

What, then, should business and industry expect from us? Certainly they can expect us to produce more and better scientists and technologists for them and more and better industrial processes and products. But, beyond this, they should expect freedom and integrity within our own domain. If we lack these, we cannot possibly merit their confidence and aid. There is much discussion regarding academic freedom in the colleges. This freedom, formerly a matter of faculty concern within the confines of the campus, has sudde become a topic for popular debate by laymen. Their attention has been directed to the subject by congressional committees investigating subversive activities in the colleges. Invasion of the hallowed halls of learning by outsiders was viewed with alarm in many quarters. It was interpreted by some as a violation of academic freedom, the long-established and necessary privilege of the teacher. There was great—and justifiable—fear that the investigations would take the form of "witch hunts" and "fishing expeditions." There was anxiety that the committees, without evidence or reason, would descend at random upon the colleges and disrupt their operations and seriously impair faculty morale. No college president welcomed the prospect of such performances, and apprehension that they were forthcoming led to many expressions of hostility regarding the intentions of the investigators. By now there has been opportunity to observe the functioning of the committees, and the atmosphere clouded by heated discussion is beginning to clear. It appears, at this time at least, that few of the dire predictions have materialized.

So far, it seems that the committees have limited their activities to the revelation of facts. As long as they remain within that boundary and do not wander afield attempting to dictate teaching content or method and as long as they do not interfere with faculty selection, retention, or discipline, it seems that minimum criticism should be generated. To me, it is inconceivable that any academic administration would knowingly hire or retain a member of the Communist Party. The blind loyalty demanded of a Communist makes him useless as a teacher, for he is incapable of exercising freedom of thought. An independent and inquiring mind is essential equipment for a scholar, especially at the college level. Without it, a teacher is of little value to his institution. Thus college officials should be concerned with the identification and removal of any person on their staff who is a member of the Communist Party. Congressional committees, being legally constituted bodies with designated authority and extensive investigative facilities, in some respects can be viewed as rendering a service to academic institutions if their activities result in identification of such undesirables.

The principal basis for criticizing such committees is their method of operation. Generally deplored is the lack of legal procedures and right of cross-examination. However, the deliberations of the committees *have* revealed Communist faculty members in some institutions, so it cannot be argued that their creation was entirely unnecessary. Let us hope that the present defects in committee operation will be remedied so that any future sessions will be conducted on a more satisfactory basis. Regardless of any past, present, or future shortcomings of the committees, however, faculty members should cooperate with them.

Less distrust would exist if laymen (including congressmen) would recognize that effective teaching is possible only when we give students the opportunity to learn the complete truth about any subject. This entails presentation of all facts, beliefs, and doctrines, including those that are unpopular. To do otherwise would be to impose restrictions on learning, restrictions that cannot be tolerated by any organization that considers itself an institution of learning.

Academic freedom is a necessity in the teaching profession, but we should remember that it is also a privilege. Like most privileges, it can be lost if it is abused. Each of us is under the serious responsibility of exercising our privilege of academic freedom only when operating in our particular areas of competence. Outside these areas we all are laymen and should conduct ourselves accordingly.

Thus, balancing our privileges and our rights, we have well-defined responsibilities. In keeping with their ever-present intent to render useful services, educational institutions will accept those responsibilities. In doing so, they accept also the challenge that faces education, the challenge to participate more intimately in the affairs of the community, the nation, and the world in order to contribute to the solution of our prevailing problems. Meeting this challenge successfully requires nothing more—and nothing less—than a continuing spirit of service.

I believe we *can* meet it, as we have met challenges in the past. I believe we *will* meet it, and go on meeting other challenges as they arise in the future.

THE ELECTROMAGNETIC SPECTRUM IN CHEMISTRY

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ONE of the major topics of chemical physics is the interaction of matter and radiation. While it appears that the essential nature of the electromagnetic waves does not change over the whole of the observable spectrum, their interaction with matter changes very markedly from one region to another. This is a consequence of the range of energy levels which play a determinative role in the structural organization of material systems. Given the Bohr relation, $E = h\nu$, it is not difficult to understand why the most significant effect of slowly varying fields is the linear displacement of charged particles or the angular displacement of dipoles (*i. e.*, small changes in the (classically) continuously variable linear or angular momenta of particles) while the highest frequencies are able to shake apart even the constituents of atomic nuclei.

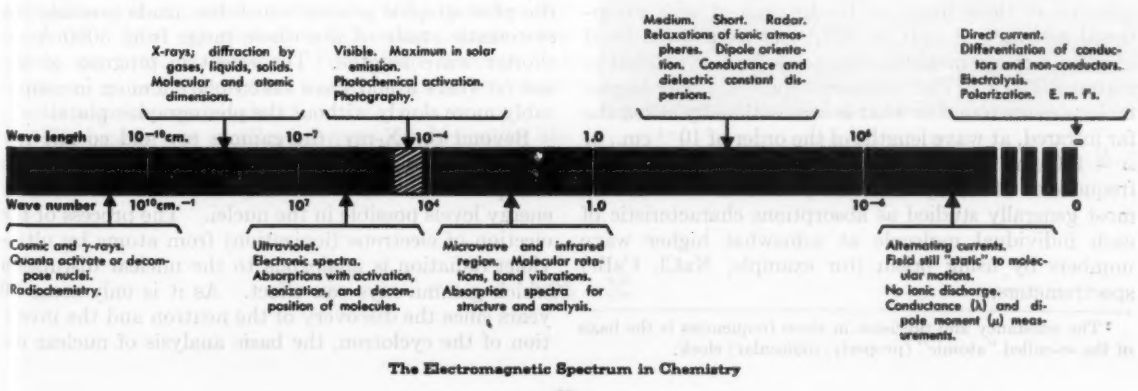
The overriding characteristic of the electromagnetic spectrum is the velocity of propagation of the waves, $c = 3 \times 10^{10}$ cm. per sec. For most chemical aspects it suffices to treat the waves as electrical oscillations of sinusoidal form, taking place transversely to the direction of propagation. The associated magnetic oscillation lies in the plane perpendicular to that of the electric field. With their constant velocity, the waves are sufficiently described either by their length (λ) in cm., representing the distance from crest to crest in the wave displacement, or alternately, by their frequency (ν) in sec.$^{-1}$, *i. e.*, the number of waves passing per second. These are of course related by: $\nu\lambda = c$. In various regions it is convenient to use multiples or submultiples of the centimeter in designating λ; *e. g.*, km. = 10^5 cm.; μ (micron) = 10^{-4} cm.; Å. (Ångström) = 10^{-8} cm. Another unit closely related to the preceding is the wave number (ω), defined as $\omega = 1/\lambda$ (*i. e.*, the number of waves per cm.), whose dimensions are thus cm.$^{-1}$, and $\omega = \nu/c$. It may be recalled that the total energy needed to give one quantum to each molecule in one gram mol, $Nh\nu = Nhc\omega$, is the einstein. This energy measure is clearly proportional to the frequency or wave number and is, in the chemical units of calories per mol, conveniently related to the wave number by the constant factor Nhc. The einstein for $\omega = 1$ cm.$^{-1}$, or $\lambda = 1$ cm., is 2.858 cal. per mol.

Some of the salient points of interest to the chemist in various regions of the electromagnetic spectrum are indicated in the figure.[1] It need scarcely be emphasized that the regions are arbitrarily defined, even the visible range varying from one individual to another and more markedly from one species to another. It is equally clear that the various regions arise from the changing reactions of matter to the radiation. The size of the particles which can be moved by the waves decreases from microscopic or colloidal, through molecular, to electronic and nuclear as the wave length decreases from very large (infinite for direct currents) to very small values.

An appreciable fraction of a systematic course in physical chemistry can be traversed by following the continuous line of the spectrum, and it must suffice here to comment briefly on some items.

Of the chemical effects of a direct current ($\nu = 0$, $\lambda = \infty$), those of electrolysis and electrode polarization by ionic discharge are especially characteristic. The generation of direct currents by chemical change, studied in the e. m. f. measurements of cells, is a typical instance of emission, *i. e.*, the reverse process of absorp-

[1] A chart of this kind can well take its place in the lecture room alongside the periodic table.


X-rays; diffraction by gases, liquids, solids. Molecular and atomic dimensions.
Visible. Maximum in solar emission. Photochemical activation. Photography.
Medium. Short. Radar. Relaxations of ionic atmospheres. Dipole orientation. Conductance and dielectric constant dispersions.
Direct current. Differentiation of conductors and non-conductors. Electrolysis. Polarization. E. m. f's.
Wave length
10^{-10}cm.
10^{-7}
10^{-4}
1.0
10^{4}
Wave number
10^{10}cm.$^{-1}$
10^{7}
10^{4}
1.0
10^{-4}
0
Cosmic and γ-rays. Quanta activate or decompose nuclei. Radiochemistry.
Ultraviolet. Electronic spectra. Absorptions with activation, ionization, and decomposition of molecules.
Microwave and infrared region. Molecular rotations, band vibrations. Absorption spectra for structure and analysis.
Alternating currents. Field still "static" to molecular motions. No ionic discharge. Conductance (λ) and dipole moment (μ) measurements.

The Electromagnetic Spectrum in Chemistry

tion of radiation. Most frequently, chemical potential is degenerated into heat. This, at room temperatures, is characterized by wave lengths of the order of 10 μ ($\omega = 10^3$ cm.$^{-1}$), but it may appear initially, *e. g.*, in chemiluminescent systems, at the far higher frequencies of the visible or ultraviolet regions. Similarly, nuclear reactions produce gamma or cosmic rays.

The molecular response to alternating fields of frequencies below about 3×10^4 sec.$^{-1}$ ($\lambda \geqslant 10$ km.) is very similar to that for static fields, because the times of oscillation of the field, 10^{-4} sec. or more, are much greater than the intervals needed by the ions or molecules to adjust themselves to the changing fields. As detection and amplification of these frequencies in electrical bridges is often far more convenient than the use of direct currents, they are of great service in conductance and dielectric measurements. The latter provide the means of determining permanent molecular dipole moments.

As the frequency increases up to 3×10^{10} sec.$^{-1}$ ($\lambda = 1$ cm.) the equilibrium distributions of ions (*i. e.*, the Debye-Hückel ionic atmospheres) and the rotation of polar molecules fail to keep up with the rapid oscillations. Accordingly, typical dispersion effects appear, the conductance or dielectric constant changing with the frequency. The lack of synchronism between oscillating field and dipole rotation results in electrical energy's being dissipated in the medium—*i. e.*, dielectric absorption (or dielectric loss) occurs. This is a maximum for *approximately* that frequency whose time of oscillation coincides with the time taken by the dipoles to turn around when the field is instantaneously reversed.

When the wave lengths become of the same dimensions as the conductance and dielectric cells and other items used in studying the behavior of materials, the conventional bridge methods have to be replaced by wave guide techniques. This change comes in at wave lengths of about 1 meter or $\nu = 3 \times 10^8$ sec.$^{-1}$ Wave lengths below 1 cm. encounter typical quantized responses. First, the natural rotations of molecules in the gaseous state are observed, as contrasted with the electrically imposed dipole orientations in liquids at much longer wave lengths, giving rise to very sharp absorption lines from whose positions the moments of inertia of the molecules may be evaluated. The frequencies of these lines can be determined with exceptional accuracy (1 part in 10^8),[2] and from them bond lengths in many molecules have now been evaluated to within 0.001 Å. The rotational spectra of the lighter molecules are found in what is conventionally called the far infrared, at wave lengths of the order of 10^{-2} cm., or $\omega = 100$ cm.$^{-1}$ Here they overlap with the vibrational frequencies of heavy molecules, vibrations which are most generally studied as absorptions characteristic of each individual molecule at somewhat higher wave numbers by using prism (for example, NaCl, CsBr) spectrometers.

[2] The constancy and precision in these frequencies is the basis of the so-called "atomic" (properly, molecular) clock.

The visible region is best given as 3800 Å. to 7800 Å. Its range defines no unique effects. The quanta on absorption now produce electronic excitation of the molecules, the energies being such as correspond to great activation of the molecules chemically without being so large as to involve their radical disintegration. It is no mere chance that the principal absorption of chlorophyll is centered at about 4500 Å., which coincides with the maximum in the solar emission. The resulting photochemical activation is the starting point of almost the whole of our planet's life processes.

With a notable exception in the case of the rare earth atoms, only the outer electrons are involved in visible absorptions or emissions. On going to shorter wave lengths in the ultraviolet, the larger quanta can excite the deeper electrons and strip them from the atoms. In the very far ultraviolet the spectrum of a copper atom which has lost 19 electrons has been observed in intense electric discharges. Of far greater chemical interest are those spectra in the ultraviolet analogous to the Balmer series for the H atom, in which an electron of a polyatomic molecule is observed at a succession of levels preceding ionization. The study of these molecular Rydberg-series spectra provides a source of precise information concerning the states of bonding and non-bonding electrons, and has contributed basic features to current quantum theories of valence. The ultraviolet absorptions are the principal cause of the refractive-index dispersion in the visible region. Very intense absorptions are found, for instance, when the delocalized electrons of extended conjugated systems are involved.

With further decrease in wave length, the dimensions of molecules and atoms are reached in the X-ray region. Here any regularity in the distribution of atomic centers in the gaseous, liquid, or solid states gives rise to diffraction effects in the radiation scattered by the material. Most simply, in the solid state where the regularities in atomic and molecular patterns are greatest, the principal effects can be treated in terms of a reflection of the radiation from the families of atomic or molecular planes, the condition for which is given by Bragg's relation. X-ray structure analysis has contributed more to the advance of chemistry in this century than has any other single technique. Even more generally, it is the photographic process which has made possible the systematic study of the whole range from 3000 Å. to shorter wave lengths. The scientific progress of the last 50 years would have taken place almost incomparably more slowly without the photographic plate.

Beyond the X-ray, the gamma ray and cosmic ray region extends, as far as we know, without limit. Here the quanta correspond to the differences between the energy levels possible in the nuclei. The process of the ejection of electrons (ionization) from atoms by ultraviolet radiation is analogous to the nuclear disruption which gamma rays can effect. As it is only some 20 years since the discovery of the neutron and the invention of the cyclotron, the basic analysis of nuclear en-

ergy levels is still in progress. The guiding principles which should result from this study will have immediate interest for the chemist in so far as they account for the relative stabilities and abundances of the chemical elements. To an even greater extent than in other parts, there must be in this extreme region of the electromagnetic spectrum interactions between matter and radiation which are as yet entirely unsuspected. The advancing study of these interactions is one of the main high-roads in physical science.

ADOLF VON BAEYER

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ADOLF BAEYER (born at Berlin, October 31, 1835) succeeded Liebig at the University of Munich in 1875. Here he built up not only the physical facilities but developed the most outstanding chemical school in Germany—perhaps in the world. He trained many leaders of the growing German chemical industry and an astounding number of the most distinguished university teachers and investigators came from his circle of students. He had an uncanny ability to pick out men of promise and to keep the inept at a distance. He was the leader of the movement to insure a high quality of chemical instruction throughout all of Germany.

His work on phthaleins, acetylene, indigo, the constitution of benzene, oxonium compounds, etc., testifies to his caliber as an organic chemist. His strain theory rendered yeoman service for many years. He followed the advice he gave his young associates: "Whatever you choose, do not seek to carry out easy tasks; devote yourselves especially to difficult problems." He was a master in limiting himself to the essential things; he had no love for the complicated. Test-tube experimentation was his specialty. He once wrote: "What makes the great scientist? He should not dominate but listen, and adapt himself to what he has heard and change himself accordingly. The old empiricists did this, they laid their ears to nature. The modern scientist does the same, and I have tried to follow this method. Men are affected in a peculiar manner when they get close to nature. They then develop in a manner quite different from one who approaches nature with a preconceived idea."

His health was excellent throughout his entire life. Not until he reached 80 did the infirmities of old age become insistent enough to lead to his retirement. He died on August 20, 1917, and is buried in the Waldfriedhof in Munich.

EIGHT CONTROLS FOR SPEAKING IN PUBLIC

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AT A banquet not so long ago I sat next to the principal speaker. He is an engineer, nationally known in the business world, a man of force and power. He was displaying anything but confidence, toying with his food, only half responding to my attempts to make conversation.

Finally he spoke his mind. "I never enjoy these affairs," he said. "If only I didn't have to make speeches! It worries me for a week beforehand."

And several weeks before that a young man of 35, an engineer also, had come to my office seeking help. He didn't look happy, and he wasn't. He had to make a speech. He had to make a speech before our local Women's Club—and he was scared to death.

What was it that made these engineers feel so inadequate?

The answer seems to lie in a situation we would never permit in our business and professional life. It's a lack of planning. Coupled with this is a lack of what I would like to call assembly-line methods.

A speech is as much a product as a can of soup or an automobile. Today the can of soup is made in a modern, streamlined factory, not in a cramped farm kitchen; the automobile is put together in a huge plant on an assembly line, not in a backyard shop. Both the can of soup and the car are produced in decisive steps, always in the same order, with the same precision, and with certain controls along the way to insure uniformity and a standard quality. The controls are as important as the steps, for by them the manufacturer can test his product. What we need in our speeches is a system of controls.

A speaking engagement made in May is often regretted in September. In May it looked easy; it was even flattering to be asked to appear in front of an audience. But when September rolls around, the audience is likely to become a many-headed monster.

Yet all of us have to make speeches. Whether we like it or not, if we occupy positions of any consequence, we will have to make speeches. And the nervous anxiety that so often accompanies the fine art of speaking is neither rare nor selective. It attacks the young and the old, the rich and the not so rich. Any methods that can be devised to reduce our tensions are worth trying. The assembly line technique with its controls seems to provide an answer.

Let's return to that young engineer. He had written out his speech, and was clutching it in his hand. I glanced at it. It began: "My topic this evening is..."

I asked him this question. "When you see a display of some sort, what strikes you first?"

He answered without hesitation. "The amount of work that's gone into it in order to appeal to the public taste."

So I submit that the first step that the engineer should think of in speech making is to make a test of the public taste. That's our first stopping place, our control No. 1. Translated, it means knowing our audience. Get to know your audience, those people who are going to come together to hear you speak. Find out as much about them as you can before you even pick your subject, so that, when you come to talk you will feel confidence in your choice of a subject.

But an audience is only an audience, you say. Not on your life! Any actor will tell you differently. He will tell you that there is the supercritical first-night audience; the beginning-of-the-week audience out to enjoy itself; and the dread of all actors, the benefit audience, a captive audience if there ever was one. You're in a far better position than the actor, however. His audiences may vary, but he has to say the same things over and over, night after night. You, on the other hand, can change your speech to meet the demands of the people you're addressing.

What did the program chairman say when he asked you to speak at the annual company dinner? He said it was to honor the retirement of a member of the firm. That's a kind of bitter-sweet occasion. It will be quite different from the salesmen's convention you attended last week. That brings us to control No. 2. What is the occasion?

Place has something to do with it too. In one of his books, that great humorist, the late Stephen Leacock, tells how he contracted for a speaking tour of Canada. On one of his dates he discovered that he was to talk in a church. Unfortunately for him his audience had been conditioned neither to laugh nor applaud in church. So Leacock had to suffer through a miserable hour, delivering wit and humor to a group of people with frozen masks for faces, and with their hands tucked under them.

It's almost regulation that certain occasions call for certain types of speeches. Memorial days, anniversaries, awards—one expects to be inspired and uplifted. Here's where you can use that poem that struck your fancy. But if you're to speak to a group that's out for information, make it sensible and forget the frills.

There's a speech for every man, and a man for every speech. Here is where we apply control No. 3. Choose a subject that interests you. Don't let anyone impose his special interests upon you. Choose a topic so interesting to you that you can forget yourself

in the thrill of getting across something you are dying to say to people who are willing to listen to you.

Tremendous enthusiasm on your part will usually set the coldest audience afire. We were neither mountain climbers nor nature lovers; yet a talk I remember with delight was on the very subject of mountain climbing. So dramatic was the telling, and so vital the speaker, so wrapped up in his subject, that all of us were inspired to go out and do likewise—at least while we were sitting in our comfortable chairs.

A variant on the old adage that you can lead a horse to water is that you can put merchandise in the store window but you can't necessarily get the people into the store. That is, not unless you do something to attract their attention and whet their appetites. In the window it may be the shimmer of tinsel, the gleam of chromium or the price tag. Apply the same technique to the speech. First attract attention—control No. 4. Perhaps it's a story that will make them sit up and pay attention. Everyone likes to hear a story. So the engineer should get into the habit of watching the newspapers and the magazines for the story with a point. I have in front of me a printed speech that begins: "A few months ago, on one of my usual lecture tours through the United States of America, my car suddenly developed engine trouble on the winding highways of southern Indiana." The speaker, Nicholas Nyardi, former Minister of Finance, Hungary, goes on to illustrate by example the cooperation he received in his attempts to spread international good will.

There are other ways of getting the speech off to a good start. Think of that audience out there in front as being a little complacent, a little smug. What can you say that will get their attention? Something contradictory to their composite beliefs, something startling, something that takes on the flavor of Ripley's "Believe It or Not." "The most important thing that has happened since the birth of Christ is the birth of America," starts a talk by Fred G. Clark, of the American Economic Foundation. And Robert R. Young prods his audience with: "This is the year of a faint glimmer of Truth In Politics."

At this point we must pause and consider some work that should have been done in advance. How do we put the speech together? "I have so much material I don't know what to do with it," is a common complaint.

The speech is the meat surrounding the bone, the digestible material around the kernel. That kernel is the most important single element in your speech. What do you want to say? Some speakers announce what they want to say in the opening sentence; a good technique for the straight information speech, but lacking in originality. But whether or not the audience gets the topic of your speech at the outset you yourself must know it.

This then is control No. 5. Examine your speech material and see if it can be condensed into one single thesis sentence. If it can, you have a center to your speech. Arrange everything around that. Ruthlessly cut out anything that won't clothe the central kernel, or idea. The wonderful material, the anecdotes and stories which we must abandon if we follow this rule! They are dear to us—but confusing to an audience. Haven't you had the impression at times that speakers have been enjoying themselves at your expense, that they were sharing some private information with themselves? Don't let it be said of you.

So it doesn't make a great deal of difference how your speech material gets put together: whether it's chronological, or whether it's arranged according to importance, or whether you're building up to some climax. The material will shape itself if you will toss into the discard anything that doesn't really belong.

We're on our way now. The speech is off to a good start. But it isn't entirely clear sailing from here on. Let's change the metaphor. You're the authority, you know the path through this material you've collected, but do your listeners? You must give them signs to follow, guides to help them along. Show them the twists of logic, the transitions of thought, by providing signposts just as the Highway Department provides signs for you.

This is where we halt our assembly line to examine control No. 6. What are these signs? They are verbal signs such as *although, but, one, two, three.* "I shall divide my talk into three parts," you say, and the audience is on the alert to discover these three parts as you go along. There are all kinds of verbal signs which tell an audience when you require it to turn a corner and get an idea fast, or climb up a hill of vital statistics with you.

The heart of any speech is the examples used in it. It's not enough to give the audience the main points. You must visualize for them. Think how effective visual aids are: slides, 16-mm movies. But you can't provide every talk you give with slides; nor would you want to. But you can do the next best thing. You can supply pictures for the mind's eye. This is control No. 7: every time you introduce a main topic or attempt to drive home an idea, see if you have provided a good concrete down-to-earth example. Four main issues to your speech: at least four examples. Make them vivid and colorful. Use familiar words, action words, picture words. Put yourself into the picture—even if you have to use your imagination.

At the end of the speech is control No. 8. I have heard it said that when you haven't anything more to say, you should sit down. It doesn't always work out that way. An audience usually demands more. For most speeches it is essential that the audience feel that something has been demanded of it, anything ranging all the way from simply being asked to think about a proposition to a much more positive demand such as canvassing for the Red Cross. So make the ending sharp and decisive, together with a request for some action on the part of your listeners. If you have been passing out information, it may be necessary to provide a summary of what you've said. If you have been arguing a cause, come to some conclusion; if you've

been entertaining and amusing, end with a story. As has been said of the departing guest; go out, don't ooze out. We usually remember the last things that are said to us. Make your audience feel that it is parting company with a decisive personality and a decisive speech.

In any analysis of public speaking, many more factors enter. We could talk of diction, voice quality, the use of gestures. The person who has mastered all of these qualities has become a showman. But most of us look upon public speaking as an adjunct to our lives, something we are called upon to do from time to time.

As you prepare your speech, then, stop at the control points and see if your speech is running smoothly along the assembly line. The controls are these: (1) learn the tastes and interests of your audience; (2) consider the suitability of your topic to the occasion; (3) choose a topic that is of great interest to you; (4) take special pains with the beginning of the speech; (5) arrange the material around a central idea—and stick to it; (6) help the audience along by means of transitional devices; (7) make it a rule to develop an example for every main point you make; and (8) keep your ending sharp and positive, and a challenge to your audience.

Check these controls, so that the next time you are scheduled to make a dinner speech you can enjoy the dinner and the audience can enjoy your speech.

WOLFGANG LANGENBECK

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WOLFGANG LANGENBECK, son of a physician, was born at Göttingen on June 21, 1899. He early developed an interest in chemistry, largely through the influence of Dr. Hartung, his teacher at the Göttingen Gymnasium whose classes were notable because of the well chosen and striking demonstration experiments. At the University of Göttingen, where he studied from 1919 to 1923, his teachers were Windaus, Wienhaus, Borsche, Tammann, and Pohl (physics). His Ph.D. was taken in 1932 under the direction of Windaus; the dissertation dealt with new methods for synthesizing imidazoles. The course of Langenbeck's future independent researches was laid by the scientific inspirations of the Göttingen faculty, particularly Windaus. A year as assistant at Karlsruhe under Freudenberg and Goldschmidt was of great profit. Then followed a long stay in the United States as Rockefeller Fellow. Langenbeck worked at Yale and then at the Agricultural Experiment Station in New Haven, under the direction of Osborne and Mendel (1924–25).

Returning to Germany, he served as assistant and later as director of the organic laboratory at the University of Münster (1926–35) under R. Schenck. Here he became Privatdozent in 1928, with a study of organic catalyzers as his habilitation essay. In 1935 he was called as professor to the University of Greifswald, and in 1940 accepted a call to the Technische Hochschule in Dresden. In 1947 he went to Rostock where he remained until 1951 when he accepted his present post as head of the Institut at the University of Halle.

Following his initial independent researches on the constitution of pilocarpine and isopilocarpine, and the configuration of histidine, Langenbeck (since 1926) has devoted his research efforts mainly to the chemistry of organic catalysts. This field had been practically ignored in comparison with the chemistry of heterogeneous inorganic catalysts. However, the catalytic action of definite organic materials has a particular interest in enzyme chemistry. In isatin, ortho-quinone, and their derivatives, he discovered materials which have dehydrase action, and similarly he found that primary amines exhibit carboxylase action along with carboligase action. By systematic substitution, the activity of such materials was enhanced almost to the enzyme action state. Such activations, combined with a raising of specificity, were attained also with hemin by addition of substituted imidazoles. These experimental studies led eventually to the "primary valence theory" of the desmolase actions, a concept which proved its value with the discovery of each new enzyme. His well known monograph "Die organischen Katalysatoren und ihre Beziehungen zu den Fermenten" appeared in 1935; the second edition was published in 1949. The latest compilation of this special field of Langenbeck's interest is contained in "Advances of Enzymology" (Volume 14, 1953).

Since 1936 he and his co-workers have been studying

the technical applications of organic catalysts, particularly with regard to the synthesis of fats. In this connection, he investigated the mechanism of the oxidation of paraffin, and demonstrated that ketone-hydroperoxides are formed as the decisive intermediate stage in this oxidation.

As early as 1932, he discovered the exceptionally high affinity of imidazole for hemin, a fact of great importance with respect to the constitution of hemoglobin and other hemoproteids. The protein segment is bound to the hemin through the imidazole nucleus. Recently, he found that there is a steric hindrance in the formation of metal complexes. All 2- and 4-substituted imidazole derivatives were found to be sterically hindered in the addition to hemin and iron-phthalocyamin.

His "Lehrbuch der organischen Chemie" was composed 1936–38. It is now in its 14th edition. Through his efforts, an Institut für Katalyseforschung was erected in Rostock in 1949. He still serves as the director of its organic section; the inorganic section is headed by Günther Rienäcker (THIS JOURNAL, 26, 666, 1949). One of Langenbeck's first discoveries in this laboratory was that of "mixed formate contacts." Mixed crystals of nickel formate and magnesium formate, after reduction in a stream of hydrogen, yield hydrogen contacts which are more active than Raney nickel.

Professor Langenbeck is a member of the Deutsche Akademie der Wissenschaften in Berlin and of the Akademie der Deutschen Naturforscher (Leopoldina). At present, his main activity is the supervision of the erection of a large building for teaching and research in chemistry at the University of Halle.

SAFETY IN CHEMICAL LABORATORIES

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University of Illinois, Urbana, Illinois

SAFE practices in academic chemistry laboratories assumed a more realistic meaning to the more than one hundred chemistry professors present at the Fourth Annual Chemistry Workshop at Pennsylvania State College. This awakening to a need for constant vigilance in the college laboratory came as a result of the safety forum held during three days of the conference under the leadership of safety engineers from three industrial concerns. Fred T. Marshall of Monsanto Chemical Co., Robert Neary of Linde Air Products Co., and J. V. Leonard of E. I. du Pont Co. pointed out to the group of chemists that whereas safe practices are known to most chemists, this knowledge is not sufficient in itself to prevent serious accidents to students and instructors. What is needed is a frame of mind which dictates "safety" at all times. This need is pointed up by the fact that one person is killed every six minutes and someone is injured every three seconds by accidents.

In industry this frame of mind is prevalent, owing to the constant pressure of an active safety organization whose sole purpose is to make money for the company by saving money which would otherwise be lost by accidents. The industrial employee realizes that both his job and his physical well-being depend on his constant attention to such simple rules as wearing eye protection at all times, using safety shields, determining the toxicity of an unfamiliar chemical before using it, etc. As a result, a worker is in less danger at his job than anywhere else.

To the manufacturer, money lost because of accidents includes not only that owing to liability for compensation and disability payments under existing workmen's compensation laws but losses from diminished production as a result of absence, etc. The panel members pointed out that there has been a general increase in the number of personal damage suits based on accidents in other than industrial locations and it was their opinion that educational institutions would soon feel this trend. In the case of state institutions such damage suits might be directed against the individual instructor, since a state organization could not be sued without its consent. This problem is the subject of an extensive report in the Transactions of the National Safety Council on "Legal responsibility of teachers with reference to their students," a reprint of which can be obtained from the council for 46 cents.

The panel members pointed out that industry accomplishes its record of continued decrease in accidents by having a definitely organized program including the collection of accident data, the removal of hazards, the

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provision of proper safety devices and protective equipment, and the use of safe operating procedures and teaching programs designed to keep the worker in the proper frame of mind. Such a program does not need to be elaborate and expensive, and a number of suggestions were made on how a chemistry department could start one. The first suggestion was that some member of the department be appointed responsible for the program. Second, an accident-reporting procedure should be worked out. Any accident corresponding in seriousness to those an industry would consider as lost time should be investigated, with the report indicating what happened and, most important, what should be done to prevent recurrence. Copies of these reports should be forwarded to the National Safety Council so that this central agency may build up a file of accident experience available to all through the Council's section on School Safety, its Safe Practice pamphlets, and its News Bulletins. One of the panel members indicated that he could find no such data in the Council's files at the present time.

A third suggestion was the organization of a safety committee, including students, to conduct periodic inspections of the laboratories not only from the housekeeping standpoint but also for studying the safe practices being followed. The committee preferably should have a changing membership so that a large number of students would be involved. This committee would serve the dual purpose of providing student participation in the safety program and giving a training ground where a sound attitude to safe practices would be inculcated in the student, especially in graduate students.

The industrial safety engineers indicated a more than passing interest in encouraging safety training in college and university chemistry laboratories. This interest stems from the indifferent attitude toward safe practices of most beginning technical employees in the chemical industries. It seems that new Ph.D.'s are the most difficult employees to convince that safety precautions are essential at all times while on the job. This situation is probably a result of an equally indifferent attitude prevalent in the chemistry department where the employee received his training.

Such an indifferent attitude may arise from the fact that no serious accident has occurred recently or that the staff is just not aware of potential dangers. In cases such as this, some representative of the department should spend a day with the safety committee of some large industry, become aware of the need for an active program, and become imbued with the desire to awaken his academic colleagues from their lethargy regarding safety. The industrial safety representatives at the Workshop indicated a willingness to cooperate with colleges by having as their guests for a day any instructors who are interested in starting a safety program in their department. It was made clear that the initial move should be made by the individual instructors. They should contact the safety engineer of a nearby industry.

Finally, the industrial representatives gave many hints on the provision of emergency and protective equipment. Emergency equipment such as safety showers and fire extinguishers are of course an integral part of the design of a good laboratory. Studies have shown that a clothing fire can be extinguished ten times as rapidly with a good shower as with a "fire blanket." Such a shower should be fed by a one-inch water line which does not run close to steam pipes. The valve controlling the shower should be of a quick-opening type which automatically stays open when released.

Types of eye-protective equipment should be thoroughly studied. Light, comfortable plastic goggles of various types are available which provide good eye protection. An essential factor in enforcing the use of such equipment is the example set by the instructor in wearing the equipment. Guides to the proper selection and use of protective equipment for other hazards are given in the references below taken from *Chemical and Engineering News*, Volume 29, page 2381, June 8, 1953.

"Accident Prevention Manual for Industrial Operations," National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.

BRANDT, ALLEN D., "Industrial Health Engineering," John Wiley & Sons, Inc., New York.

"Chemical Safety Data Sheets," Manufacturing Chemists' Association, Inc., 246 Woodward Bldg., Washington 5, D. C.

CROSBY, FISKE, AND FORSTER, "Handbook of Fire Protection," National Fire Protection Association, 60 Batterymarch St., Boston, Mass.

JACOBS, M. B., "Analytical Chemistry of Industrial Poisons," Interscience Publishers, Inc., New York.

"The Merck Index," Merck and Co., Inc., Rahway, N. J.

"National Fire Codes," and "N. F. P. A. Inspection Manual," National Fire Protection Association, 60 Batterymarch St., Boston, Mass.

PATTY, FRANK A., "Industrial Hygiene and Toxicology," Volumes I and II, Interscience Publishers, Inc., New York.

PERRY, JOHN H., "Chemical Engineers' Handbook," 3rd ed., McGraw-Hill Book Co., Inc., New York.

"Safety Codes and Standards," American Standards Association, 70 East 45th St., New York 17, N. Y.

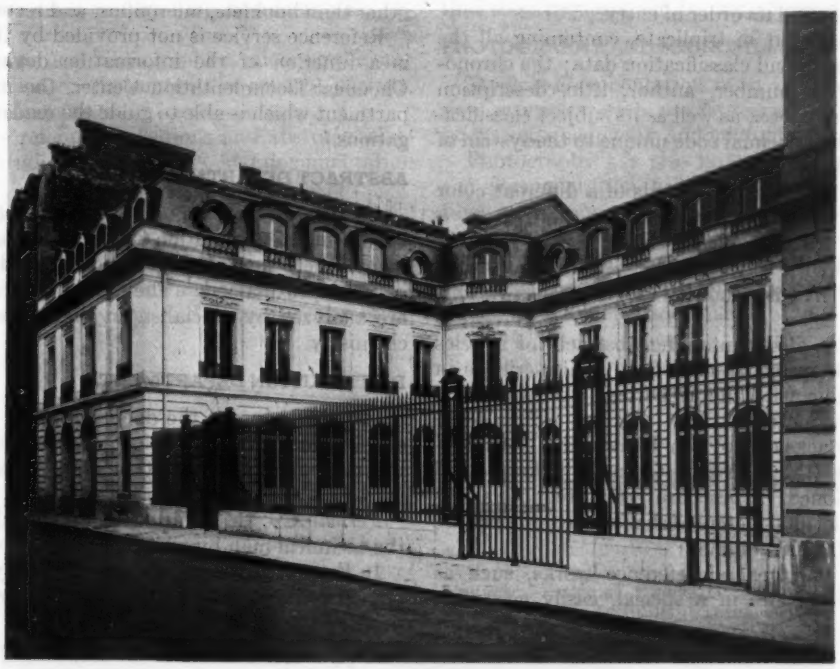
"Safe Practice Pamphlets," National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.

Additional references are to be found in "Manual of Laboratory Safety" published in 1952 by the Fisher Scientific Co. and available free from them upon written request.

♡ ♡ ♡

DOCUMENTATION AND BIBLIOGRAPHY IN "LA MAISON DE LA CHIMIE"

MAURICE V. P. DESCHIENS
Paris, France



The House of Chemistry

In the International House of Chemistry, first opened in Paris in 1934, with the moral and material aid of 65 nations, the first effort was made to create an international and scientific family life.

In a vast library of international value, which is a treasury of science, of wisdom, and of imagination, the vision of the productive worker can extend till the past joins the present, to throw a bridge between the various nations, opening the way to mutual comprehension and peace.

Scientific, technical, and economic organization necessarily involves well equipped documentation. It is important, indeed, that a result once achieved should be preserved and made accessible to all those interested in it for their own work.

The necessary parts of a chemical documentary organization are (1) a library and depository for documents and archives, (2) an abstract department (for catalogues, files, analysis, index, monographs, etc.), and (3) a distribution department.

LIBRARY

In the House of Chemistry all national and international agencies have assembled collections of books, pamphlets, patents, and periodicals. From the start of the institution, this collection has become one of the most important and complete chemical libraries in the world.

The initial collection has been completed and is being kept up to date; it is constantly increased through acquisition and exchange. At the present moment, the library contains over 32,000 bound volumes of periodicals, and 35,000 books, pamphlets, and monographs.

We are conscious of the magnitude of the task of acquiring and adequately abstracting all the scientific publications that the world is now producing. For this reason the various collections have been carefully indexed, classified, and preserved. Such a precious deposit must be open to all research workers.

The library works in close conjunction with the Center of Chemical Documentation, also established in the

House of Chemistry, which is a creation of the Société de Chimie Industrielle (Society of Chemical Industry).

The main function of the library is to group documents, while that of the documentation center is to distribute documentary forms or information. The Documentation Center also investigates and suggests new sources of material for the library.

Each volume is given, on its receipt, a code number indicating its place on the shelves, and determined according to its size and its order of entry.

A card is made out in triplicate, containing all the important indexing and classification data; the chronological acquisition number, author, title, description and source of book, etc., as well as its subject classification according to a decimal code unique to the system of the House of Chemistry.

For volumes of periodicals, cards of a different color are prepared, containing the same information.

These cards are assembled in large frames properly protected, in such a way that they are readily visible and accessible. A color code divides them into various classes.

Cards are also filed containing abstracts of articles from periodicals, properly classified. This series is in close coordination with the activities of the Chemical Documentation Center.

The library stacks occupy ten floors in the Documentation Center of the House of Chemistry, fireproofed and air-conditioned. These are connected by elevators and provide 4000 meters of shelf space, or adequate provision for 100,000 volumes.

Dictionaries and general reference works, such as *Chemical Abstracts*, are in a special, easily accessible section of the library. Old and valuable volumes and documents are in a special room, as well as manuscripts and memorabilia of famous chemists. Manuscripts which authors have been unable to publish for some reason are also indexed and classified.

The reading hall is light, well aerated, away from outside noises, and accommodates about a hundred readers at individual tables. Several compartments are reserved for individual consultation of documents other than booklets, microfilms, and records.

Reference service is not provided by the library, but is a function of the information department of the Chemical Documentation Center, the information department which is able to guide the reader in his investigations.

ABSTRACT DEPARTMENT

All documents pass, on their receipt, through the Chemical Documentation Center and its abstract department, where they are registered, indexed, and classified as already explained. The most important documents are analyzed by specialists in the various branches of chemistry.

DISTRIBUTION DEPARTMENT

Its part is to put the documentation at the public's service through information, communication, publishing, reproduction, translation, etc. This service is both periodical and occasional.

Periodical. Information is periodically brought to the technical man by reference organs and by abstracts.

In France, abstracts are most generally used, but it is obviously impossible for us to compete with the Ameri-

Exhibits in the House of Chemistry

can Chemical Society and its remarkable *Chemical Abstracts.*

Occasional. The Documentation Center tries to be able to undertake investigations at any moment, both in the documents assembled in the House of Chemistry and in those of other institutions and various libraries or documentation centers in Paris.

It is generally able to:

(*a*) Prepare bibliographies on a given topic, in order to save the user from undertaking documentation research himself.

(*b*) Prepare critical bibliographies, allowing the user to form an opinion on the contents of reports, patents, and various documents.

(*c*) Prepare reference selections and abstract selections, critical studies of documents, and documentation reports.

(*d*) Make translations.

(*e*) Supply reproductions on paper or on microfilm.

The documentation department of the House of Chemistry was the first to issue a microcard on paper.

Interested parties may also find there many practical helps such as lists of apparatus and product manufacturers, current prices, and pertinent information concerning industrial operations.

Lastly they should be able to procure through the library, if they wish to, all French or foreign documents in their original form: books, periodicals, patents, etc.

The patrons of the documentation department have responded most favorably, for they are not only saved from much of the drudgery of their work but they know that their requests will be met efficiently.

PHOTOGRAPHY AND MICROFILMS

Modern documentation must include the use of all new processes, such as photographic reproduction of books and documents, and microfilm.

Photography has also become an important tool in the documentation field, the production of scientific films, of manufacturing processes or new techniques.

At the liberation of Paris, the American staff, knowing the many documents kept up to date during World War II in the House of Chemistry, asked for and microfilmed all the useful documents it found there.

CONFERENCE ON NATION-WIDE PROBLEMS OF SCIENCE TEACHING IN THE SECONDARY SCHOOLS

At the invitation of Dr. James B. Conant, then president of Harvard University, 22 science educators from various parts of the United States conferred on the Harvard campus from July 15 to August 12.

The Conference considered various aspects of science education, including chemical education, in the secondary schools. The Conference was financed by the Carnegie Corporation of New York, New York. Eleven consultants were brought before the Conference for their well-informed advice. They included:

Professor Stewart S. Cairns, Chairman, Department of Mathematics, University of Illinois.
Professor Philippe LeCorbeiller, Physics Department, Harvard University.
Professor I. Bernard Cohen, History of Science, Harvard University.
Professor Robert Ulich, Graduate School of Education, Harvard University.
Dr. S. Donald Melville, Educational Testing Service.
Dr. Henry Dyer, College Entrance Examination Board.
Professor George R. Harrison, Dean of Science, Massachusetts Institute of Technology.
Professor Nathaniel Frank, Chairman, Physics Department Massachusetts Institute of Technology.
Mr. Raymond Mayhew, National Science Foundation.
Dr. Lester Nelson, formerly Chairman, Ford Foundation Committee on Fellowship Awards to Secondary School Teachers.
Dr. Raymond C. Maul, Research Division, National Education Association.

The findings of the Conference deal with the problems that confront science education in the secondary schools. Topics considered by the Conference and included in its documented study are:

The nature of the problem of science education.
Teacher supply and demand.
Preparation of science teachers.
Science teaching as work and career.

The findings in some instances are projected into the future by extrapolation as far as 1966.

The Conference report, a 48-page booklet entitled "Critical Years Ahead in Science Teaching" will be sent without charge to all persons who request copies. State the number of copies desired and send a gummed, self-addressed label to Elbert C. Weaver, Secretary, Phillips Academy, Andover, Massachusetts.

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

AN ALTERNATIVE METHOD FOR THE CALCULATIONS OF INDIRECT GRAVIMETRY

B. A. FIEKERS, S. J.
College of the Holy Cross, Worcester, Massachusetts

ONE of the commonest numerical problems in indirect gravimetric analysis requires the solution for two chemically related components in a binary mixture. The data include the weight of the mixed sample, the weight of a mixed product from a reaction which is common to both components, and the gravimetric factors involved.

Solutions for such problems given in most of the textbooks are invariably based on the use of simultaneous equations. In this paper an alternative method is suggested. It has remotely the same algebraic basis, but it adapts this type of problem to a schematic technique, known as *alligation alternate*, familiar to many, no doubt, through the work of Pearson[1] and others.[2] In many cases this alternative has the advantage of being more rapid than the algebraic method and might thus be of value in routine calculations. It is a concise method and so it tends to reduce the chances of erroneous calculations. It lends itself to the rapid diagnosis of data which are physically false, and hence it is of value to the instructor who composes his own exercises. A typical exercise follows.

A mixture, containing only sodium chloride and sodium iodide, weighs 1.0238 g. It is treated in solution with silver nitrate. The weight of the precipitated mixture is 1.8979 g. Calculate the percentages of the components in the original mixture. (Once such a problem is solved, calculations can then be made for the weights of the components and for other chemically related quantities.)

Solution.

$$w_{NaCl} + w_{NaI} = 1.0238 = W_s \qquad (1)$$

$$w_{AgCl} + w_{AgI} = 1.8979 = W_p \qquad (2)$$

where w is the weight of the components designated; W_s, the weight of mixed sample; and W_p, the weight of the mixture of products. Formula subscripts identify the components in each mixture. It is well also to write equation (2) in terms of equation (1):

$$AgCl/NaCl \times w_{NaCl} + AgI/NaI \times w_{NaI} = 1.8979 \qquad (3)$$

by applying appropriate factors. The values of the factors are given by:

$$AgCl/NaCl = 2.4521 \qquad (4)$$

$$AgI/NaI = 1.5662 \qquad (5)$$

Then take the ratio, R, as follows:

$$R = W_p/W_s = 1.8979/1.0238 = 1.8535 \qquad (6)$$

A square is then constructed as shown in the figure, in which the value of R is written at the center and the values of the factors which appear in equation (3) are written in the corners to the left. Differences between the value of R and the values of the factors are taken diagonally and written in the corners to the right. These differences comprise the *ratio* of the weights of the components in the order sodium chloride, sodium iodide—not necessarily the actual weights of the components. The percentage of a given component is then calculated:

$$\%\ NaI = (0.5986 \times 100)/(0.2873 + 0.5986) = 67.5\% \qquad (7)$$

The percentage of sodium chloride can then be calculated in a fashion analogous to equation (7), or by difference from 100:

$$100\% - 67.5\% = 32.5\%\ NaCl \qquad (8)$$

Other problems can often be reduced to this form by means of chemical factors, for example, in cases where the analysis for some common atomic constituent in the sample might be given.

The value of R could be confused with its reciprocal.

[1] LANGE, N. A., "Handbook of Chemistry," 7th ed., Handbook Publishers, Inc., Sandusky, Ohio, 1949, p. 775: "Standardization of milk and cream. Pearson's square method." University of Illinois Bulletin No. 323.

[2] BRADLEY, W. T., C. B. GUSTAFSON, AND M. J. STOKLOSA, "Pharmaceutical Calculations," 2nd ed., Lea and Febiger, Philadelphia, 1952, p. 155.

The choice is correct when the value of R lies within the values of the two factors. If this condition is not fulfilled, the value of the reciprocal of R might be tried. If both R and $1/R$ are not of intermediate value, then the data are physically impossible. An equivalent criterion demands that the two terms of the ratio of the weights of the components should have *like* algebraic signs.

An algebraic justification of the method follows.

$$w_a + w_b = W_s \tag{9}$$

$$F_a w_a + F_b w_b = W_p \tag{10}$$

wherein the subscripts a and b identify the components and F is the appropriate factor. Dividing all terms in equation (10) by W_s,

$$F_a w_a/W_s + F_b w_b/W_s = W_p/W_s = R \tag{11}$$

and letting the ratio of the weight of product to the weight of sample be equal to R, it is seen that this calculated factor R is the weighted average of the chemical factors appearing in equation (10), and that its value has to lie between the values of these factors. By equation (11):

$$W_p = RW_s \tag{12}$$

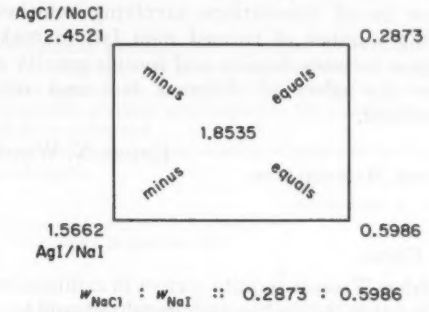
Substituting in equation (12) the values of W_p and W_s from equation (10) and equation (9) respectively:

$$F_a w_a + F_b w_b = Rw_a + Rw_b \tag{13}$$

Equation (13) is also given by:

$$w_a/w_b = (R - F_b)/(F_a - R) \tag{14}$$

in which the component weights of a and b cannot be taken separately, but only as the ratio of the weights of the two components. Equation (14) is schematized in the figure.



To the Editor:

The role of research in undergraduate chemistry education is being frequently discussed today. It would seem to me that undergraduate research can play an especially significant role in institutions such as my own. Our chemistry department provides chemical training for agriculture, engineering, and medical students. This means that we have a very large number of students taking chemistry courses (and hence a large staff in chemistry) but only a few chemistry majors.

We are therefore in a position to give more individual attention to our chemistry majors and help them get started on small research problems while they are still undergraduates. A senior research problem is required for graduation. Some typical problems studied have been construction and testing of fractionating columns, correlation of pK_b values of pyridine derivatives with structure (pK_b values measured on a Beckman DU), polarographic reduction of nitroso derivatives, hydrogenation of cottonseed oil, extraction of licorice, etc. In many cases the research problems are part of a larger program of one of the staff members and some of the work is ultimately published.

We feel that undergraduate research is a very valuable experience for our students and helps them make the transition from laboratory manual exercises to facing and solving chemical problems in their later professional life.

ROBERT H. LINNELL
AMERICAN UNIVERSITY OF BEIRUT
BEIRUT, LEBANON

To the Editor:

Your associate editor, my fellow townsman, Elbert C. Weaver, has aided and abetted the propagation of a very common error in his article on page 386 of your August, 1953, issue. I refer to his second example of Pearson's square.

Proper usage of this device is restricted to problems

in which weight units are specified. Thus the acetic acid example, based on normality, works out nicely, while the sulfuric acid solution may be shown to be 84.88 per cent rather than 82 per cent. Such an error can have grievous consequences in industrial applications.

My purpose is to point out the necessity for specific gravity in this computation and to emphasize its importance in all calculations involving solutions. A surprising number of trained men fail to make the distinction between density and specific gravity and to consider the effect of different test and reference temperatures.

EMERY N. WESCOTT

ANDOVER, MASSACHUSETTS

To the Editor:

Neighbor Wescott is quite correct in calling attention to the fact that the problem in question should be solved by weight rather than by volume.

The correct solution of the problem follows.

Problem: If 150 ml. of 95 per cent sulfuric acid is mixed with 50 ml. of 43 per cent acid, what is the per cent of acid in the mixture?

Solution:

$$150 \text{ ml.} \times 1.8337 \text{ g./ml.} = 275.06 \text{ g. of } 95\% \ H_2SO_4$$
$$50 \text{ ml.} \times 1.3294 \text{ g./ml.} = 66.47 \text{ g. of } 43\% \ H_2SO_4$$

where 1.8337 and 1.3294 are the respective specific gravities at 20/4°C.

$$\begin{array}{ccc} 0.95 & & x - 43 \\ & \searrow \quad \nearrow & \\ & x & \\ & \swarrow \quad \searrow & \\ 0.43 & & 95 - x \end{array}$$

$$95 - x/x - 43 = 66.47/275.06$$
$$x = 84.9\% \ H_2SO_4$$

ELBERT C. WEAVER

PHILLIPS ACADEMY
ANDOVER, MASSACHUSETTS

To the Editor:

"The temperature above which a gas cannot be liquefied by any pressure is called the critical temperature of that gas."

This definition appears in a widely used textbook of college chemistry. Now a moment's consideration shows that it is a false statement, for actually there are hundreds or even thousands of temperatures *above which* a gas cannot be liquefied by any pressure. The definition emphasizes how a gas cannot be liquefied rather than how it can be liquefied. Notice the clarity and correctness of this definition from another textbook: "The critical temperature of a gas is the highest temperature at which that gas may be converted into a liquid."

The examination of twenty-five textbooks of freshman chemistry reveals that twelve authors use the incorrect definition quoted above. It is to be hoped that these authors will pay attention to this topic in future revisions, and that teachers of chemistry will be alert in presenting to their students a clear definition of critical temperature.

M. E. LASH

KANSAS STATE COLLEGE
MANHATTAN, KANSAS

To the Editor:

Your editorial in the November, 1953, issue on the materialistic attitude and poor expressive abilities of our recent college graduates has prompted me to remark about the latter defect.

The lack of ability to read, write, and express ideas can only be traced to a lack of ability to think. The problem is: how can we make them think? As a partial solution to this difficult question, we use a suggestion adapted from Adler's well known treatise, "How to Read a Book." Briefly, in most laboratory reports at most schools it is customary to require the writer's description of the experimental procedure in detail. Instead of this, we require the student to write in ONE sentence a complete, succinct, almost terse description of the procedure followed. . .and no semicolons or hyphens allowed.

As a result, the student is forced to reflect at length, and even sometimes to think, about what he actually did do in following the experimental directions.

Needless to say, this is not a complete answer to the problem; and, further, this method possesses one distinct advantage: the report can be graded in less time and with less boredom on the part of the teacher.

JAY A. YOUNG

KING'S COLLEGE
WILKES-BARRE, PENNSYLVANIA

To the Editor:

Varshni's empirical rule for orientation of aromatic substitution (J. CHEM. EDUC., **30**, 465 (1953)) is essentially equivalent to that of Hoffert (*J. Soc. Chem. Ind.*, **42**, 348 (1923)), to whom priority should be acknowledged.

LLOYD N. FERGUSON

HOWARD UNIVERSITY
WASHINGTON, D. C.

• OXIDATION OF METALS AND ALLOYS

O. Kubaschewski and *B. E. Hopkins*, Principal Scientific Officers, National Physical Laboratory. Academic Press, Inc., New York, 1953. xv + 239 pp. 84 figs. 18 tables. 16 × 25.5 cm. $6.

This book serves as an excellent reference to the subject of high-temperature oxidation and is a helpful guide to the extensive literature on this subject. The authors defined their field of high-temperature oxidation to include processes occurring above 100°C., and in choosing metals to discuss found that they had most of the periodic system over which to roam. As they state: "With the exception of gold, no pure metal (including platinum) and no alloy is stable in air at room temperature. All metals tend to form oxides and many tend to form nitrides, although in many instances the rate of reaction is very slow at low temperatures.... In theory, all metallic compounds decompose at high temperatures; in practice, however, most of these decomposition temperatures are above the boiling points of the parent metals or their compounds. This means that most metals of the solid or liquid state are unstable in air at any temperature."

Here is a book in which one can find tabulated the relative stability of oxides, their X-ray structure, melting points, heats of decomposition, and molecular volume. One can find information such as the Arrhenius reaction-rate constants for metals combining with air, oxygen, and nitrogen. There is detailed information on oxidation rates of all the common metals and alloys and some information is included for the uncommon metals like cerium or thorium, or for elements like silicon, germanium, and arsenic. One learns that molybdenum can be heated to 200°C. for two hours without losing metallic luster, but at 300°C. the metal becomes steel blue in color. Tungsten, on the other hand, stays bright for two hours at a temperature of 300°C. Only CoO is found on cobalt above 900°C., but Co_3O_4 is found over a CoO layer at lower temperatures. These are among the many odds and ends of interesting data.

Most of the discussion deals with factual information; the remaining portions deal with experimental methods for determining oxidation rates and for examining oxidation products. The treatment of oxidation mechanisms brings to the fore the outstanding contribution made by the electrochemical or Wagner theory of oxidation. According to this viewpoint, now confirmed by a respectable number of experiments, metals like copper do not oxidize by simple chemical reaction, but by diffusion of Cu^+ and electrons outward through the oxide, or, what is the equivalent, diffusion of lattice vacancies inward, ultimately becoming filled by Cu^+ at the metal surface. Electrons move outward simultaneously, or the equivalent positive holes (electron deficiencies) move inward. Discussion of theory tends to be brief and is not presented from the standpoint of the beginner but rather on the level of the advanced student who knows or is not averse to looking up the literature for a fuller discussion.

This volume is written not primarily for the theoretician nor for the engineer, but is rather a synthesis of the two viewpoints. Coverage of the literature is thorough, based on a total list of references numbering 549. In view of this thoroughness, it is surprising not to find mention of the effect of Curie temperature on oxidation rates described clearly by Tammann and Siebel 28 years ago and confirmed 3 years ago for the chromium-iron alloys. Furthermore, in discussing diffusion, the authors omit mention of the Langmuir-Dushman relation for diffusion constants, although phases of diffusion seemingly less important are included. Some parts of the discussion seem more appropriate to an appendix, but in other respects the organization of material is good, and the reader is quickly oriented with respect to the phase of the subject in which he is interested.

The book will prove to be a valuable reference for both chemists and metallurgists.

HERBERT H. UHLIG

Massachusetts Institute of Technology
Cambridge, Massachusetts

• ANIMAL BIOCHROMES AND STRUCTURAL COLORS

Denis L. Fox, Professor of Marine Biochemistry, Scripps Institution of Oceanography of the University of California. Cambridge University Press, Cambridge, 1953. xiii + 379 pp. 3 plates. 37 figs. 11 tables. 16 × 25 cm. $11.

Everyone, scientist and nonscientist alike, enjoys the aesthetic pleasures afforded by the brilliant colors of the animal world: the iridescence of birds' plumage, the rich and lively hues of many fishes and reptiles, the intricate patterns of pigmentation in the bodies and wings of insects. While the layman is ordinarily content with the contemplation of these beauties, the scientist has pursued his fascination in an attempt to discern their meaning and to give an account of them as biological and chemical phenomena. Professor Fox has given an excellent summary of the enormous amount of research that has been directed toward the description and analysis of animal coloration, and he has written with a zest that betrays his own delight in his subject.

Of the 14 chapters in the book, the first five are devoted to an introduction and to a consideration of the structural colors produced by Tyndall, diffraction, and interference phenomena. The remaining chapters deal with the organic pigments: the carotenoids, quinones, anthocyanins and flavones, indigoid and melanin pigments, porphyrins and bilins, flavins, purines and pterins, and miscellaneous pigments of unknown or incompletely known structures.

The book is written with a keen appreciation of the position this area of study occupies with respect to the more rigorously defined disciplines, and gives due consideration to such diverse points of view as those of ecology and structural organic chemistry. The emphasis is chiefly biological and is largely upon those pigments and structural factors that are responsible for visible coloration. Pigments such as the flavins, which produce no gross coloration, and the purines, which are colorless but are often responsible for iridescence and structural whiteness, are treated in less detail and with limited attention to their metabolic importance.

As any good book should, this one raises questions as well as answers them. The reader will be impressed by the vast amount of descriptive information and the relative paucity of exact knowledge concerning the chemical identity or biological role of many animal pigments. The use of such terms as epiphasic, hypophasic, xanthophyll, etc., to describe carotenoid pigments, the description of echinoid quinones by means of their absorption maxima, and the many uncertainties that exist with regard to the structures of the melanins, are indicative of the great amount of re-examination and further research that would be needed to identify the multitude of pigments now recognized only as

members of classes or groups. It is probable, however, that scientists will be strongly impelled to resolve these many questions of detail only when more is learned about the physiological functions of the many pigments whose structures are already known. It is to be hoped that this admirable synthesis of the existing information in this area of biology will stimulate the formulation and resolution of the many problems that remain.

The book is well, though not profusely, illustrated with figures, mostly of anatomical sections which show the disposition of pigments or of the elements responsible for structural colors. Three handsome color plates, from original paintings, adorn the volume. The book is well made and excellently printed in a pleasing type face. An author index, an alphabetical bibliography of the approximately nine hundred references, and a detailed subject index are provided. The few minor typographical errors to be found in the first copies will be corrected in subsequent printings.

T. A. GEISSMAN

UNIVERSITY OF CALIFORNIA AT LOS ANGELES
LOS ANGELES, CALIFORNIA

● THE REVOLUTION IN PHYSICS: A NON-MATHEMATICAL SURVEY OF QUANTA

Louis de Broglie. **Translated by *Ralph W. Niemeyer.* The Noonday Press, New York, 1953. 310 pp. 14.5 × 21.5 cm. $4.50.**

THIS is the first American edition of the author's "La Physique nouvelle et les Quanta" published in France in 1937. It does indeed contain some additional material in the form of recent comments on the present situation respecting the methodology of quantum physics as well as a section on new developments in nuclear physics.

The author needs no introduction to American scientists, and even the lay public have for some time been familiar with the achievements which led to his winning of the Nobel Prize in 1929. He is, of course, one of the distinguished creators of modern quantum mechanics. In addition to his scientific researches, during the past fifteen years de Broglie has produced a number of general treatises more or less historical and semipopular in character setting forth the substance and significance of twentieth-century atomic and radiation physics. The volume under review is a good illustration of his ability to present rather difficult physical ideas in nonmathematical terms and in graceful language. This does not mean that the book is a *popular* introduction to quantum physics, as the term is commonly understood in this country. Actually it makes considerable demands on the reader's background and he will get out of it little more than aesthetic pleasure in the agreeable style if he approaches the reading without a firm knowledge of general physics on the university level. The volume exemplifies indeed one of the difficulties inherent in any attempted popular presentation of an analytical science like physics: If mathematical symbolism, the natural language of physical science, is introduced at no matter what level of simplicity, the average layman is repelled; on the other hand, if the description is conducted in terms of the language of ordinary speech, unless extraordinary skill is displayed the casual and unprepared reader may wind up in a state of hopeless confusion. There is one possible alternative: When the material is presented so agreeably and with such an obvious attempt to avoid misconceptions and oversimplifications as de Broglie employs in this book, the genuinely earnest reader may well be stimulated to go back and secure the necessary background in order really to understand what he is reading.

Beginning with a brief introduction on the importance of knowing something about quanta in order to understand what has happened in modern science, the author then reviews in a couple of chapters classical mechanics from the point of view of Hamilton (on whose work indeed his own masterly contribution of 1924 was based) and classical radiation theory (Maxwell in particular). The atomic theory and special relativity next come in for attention. In Chapter Five, quantum theory first appears in terms of the historical labors of Planck on heat radiation. Thereafter the treatment covers the usual gamut of the Bohr theory of atomic structure, its triumphs and difficulties, and the way in which it led to the wave mechanics of Schrödinger and the quantum mechanics of Heisenberg. There is a particularly interesting discussion of the indeterministic character of modern quantum theory and a brief survey of some very recent suggestions that this indeterminism may be superseded in the future evolution of the theory. The book closes with an account of the relativistic theory of the electron (Dirac) and quantum statistics.

The translation is fully adequate to the demands of the material. A few minor slips, such as the reference to Hamilton as a "Scotch geometer," might indeed have been corrected. There are no illustrations. The format and the type are good. One might quarrel with the title, for the use of the word "revolution" in physics has been vastly overdone. The book should prove of particular value to graduate students of physics and chemistry.

R. B. LINDSAY

BROWN UNIVERSITY
PROVIDENCE, RHODE ISLAND

● ELSEVIER'S ENCYCLOPAEDIA OF ORGANIC CHEMISTRY. VOLUME 12B, PART 6, SERIES III, CARBOISOCYCLIC CONDENSED COMPOUNDS, CARBOXYLIC ACIDS (COOH IN SIDE CHAIN) CONTAINING ONE NAPHTHALENE NUCLEUS

Edited by *F. Radt.* Elsevier Publishing Co., Houston, Texas, 1953. xlviii + 703 pp. (text) + 78 pp. (index). 17.5 × 26 cm. Subscription price, $50. Serial price, $58. Single volume price, $66.

THE bigoted optimist, after reading this volume, might point with scorn to the fears of 1920 to 1940 that rapid expansion of chemical investigation would result in a stale and unworkable literature. More likely Elsevier's achievement is a result of enlightened pessimism, especially since the editorial staff seems to derive from the tradition of Beilstein. At least the "Encyclopaedia" seems to have been planned to relieve much of the bleak outlook for the literature of the near future.

The schedule of publication differs sufficiently from that of Beilstein (especially in very active fields of research) that up-to-date coverage is provided by the "Encyclopaedia." Furthermore, Elsevier's method of literature classification has made it possible to include references almost up to the date of publication. The editing of the "Encyclopaedia" provides many conveniences, such as tabulations and summaries, which are not found in Beilstein, and the paper, typography, and critical presentation of the subject are distinct improvements over those of Beilstein.

The method of compound classification in the "Encyclopaedia" differs from that of Beilstein. Both start from the premises that every compound can be represented by a structure, and that such structures can be described by terminology familiar to chemists practicing in the field. Furthermore, Beilstein and Elsevier, respectively, divide organic compounds into three main divisions: acyclic (aliphatic, Series I), isocyclic (carboisocyclic, noncondensed, Series II, and condensed, Series III) and finally, heterocyclic (same, Series IV). Otherwise the systems differ wholly or partially, as is outlined on pages xix–xxi of the volume under review. While this difference means that the literature searcher must learn two systems, the reviewer believes this to be of advantage. No index or text arrangement is perfect, especially when synonyms are included. The "psychic sense" required to ensure a completely reliable search of Beilstein is either alleviated or facilitated by joint use of Elsevier's encyclopaedia.

It follows that an efficient library cannot choose between ownership of Beilstein or Elsevier; it must have both. However, when economies make this temporarily impossible, the individual volumes of Elsevier are more useful to the specialist than are individual volumes of Beilstein.

The data of Volume 12B, part 6 are derived from about 750 journals up to and including 1944, and an earlier Elsevier policy has been revised to include the patent literature. Literature concerning structure has been consulted up to 1953. These data cover the naphthalenes and hydronaphthalenes containing one or more carboxyl groups in side chains, together with their substitution products and derivatives related by what Beilstein calls the principle of anhydrosynthesis. Obviously hydroxy acids are included, but it is characteristic of the insight of the Elsevier editors into the needs of chemists that the corresponding lactones are listed, despite their heterocyclic nature. In his preface Dr. Radt assures the reader that these lactone entries will again appear in the heterocyclic series.

A letter accompanying the copy sent for review indicates that the publishers will send "this valuable but costly volume" for a "limited free examination." In view of its importance to American organic chemistry, the reviewer urges strongly that professional chemists examine the "Encyclopaedia" according to Elsevier's offer if they have doubts about its value in their libraries.

GEORGE F. WRIGHT

UNIVERSITY OF TORONTO
TORONTO, CANADA

● LABORATORY MANUAL IN PHYSICAL CHEMISTRY

Richard B. Ellis, Research Physical Chemist, Southern Research Institute, Birmingham, Alabama, and *Alfred P. Mills,* Assistant Professor of Chemistry, University of Miami, Coral Gables, Florida. McGraw-Hill Book Co., Inc., New York, 1953. vii + 94 pp. 18 figs. 21 × 28 cm. $3.50.

THIS new physical chemistry manual is primarily intended, according to the preface, to serve the needs of the small college whose physical chemistry laboratory may be lacking in some of the more elaborate items of equipment. However, the experiments presented do not indicate any notable improvisations, the equipment used being generally the same as that used in fully equipped laboratories for the corresponding experiments. Twenty-three experiments are included, with the following distribution of topics: gas laws (3), properties of liquids (6), solutions and phase equilibria (7), thermochemistry (1), kinetics (1), electrochemistry (2), surface chemistry (3). For a one-semester course, the authors propose the selection of 15 experiments which students would complete in 15 three-hour laboratory periods. If a two-semester course is to be offered, a program of 10 experiments each semester is suggested, with a correspondingly greater degree of precision and accuracy being required. Extensive use is made of unknowns.

The descriptive matter provided with each experiment is well organized and concise, the usual headings of purpose, equipment, discussion, procedure, and calculations being used. It is assumed that textbooks and handbooks are available in the laboratory, as no attempt is made to present a comprehensive theoretical or historical background, and no appendix is provided. The apparatus assemblies are very clearly represented by large line drawings and schematics. The procedures are generally familiar ones and should yield satisfactory results.

Many physical chemistry teachers may be interested in the detailed data sheets provided for each experiment. These appear to be very systematically designed to provide a neat, clear, and compact record of the results of the experiment on a single sheet of paper which is perforated for easy removal from the manual. The potential user's attitude toward this feature will depend upon his feeling as to the function of experiment write-ups in general and those in physical chemistry in particular. This reviewer believes that the experience of organizing complete reports, patterned to some extent on the form expected of scientific publications, is extremely desirable for undergraduate training in the natural sciences, and that the physical chemistry laboratory is an appropriate place for this to be emphasized.

Contrary to the intention expressed in the preface, this manual may appeal more generally to the large institutions than to the small, because (*a*) large numbers of students in the physical chemistry laboratories and the use of graduate assistants may make the standard forms an important time-saving feature, and (*b*) the availability of other courses involving individual project reports may lessen the need for them in the physical chemistry laboratory. For the smaller institution where the enrollment in this course permits, the instructor may prefer to operate the physical chemistry laboratory in such a way as to simulate a research situation, with detailed directions at a minimum and the student encouraged to select and develop his own experimental methods.

AMBROSE R. NICHOLS, JR.

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● CHYMIA. VOLUME 4

Henry M. Leicester, Editor-in-Chief. University of Pennsylvania Press, Philadelphia, 1953. viii + 217 pp. 14 figs. 16 × 24 cm. $4.50.

OF THE ten contributions to this volume, five are biographies, of Madam Lavoisier (by Denis Duveen), Benjamin Rush (by Wyndham Miles), Auguste Laurent (by the late Clara de Milt), Charles Caldwell (by Herbert Klickstein), and Maxwell Simpson (by Desmond Reilly).

In a chapter "On the origin of alchemy," R. J. Forbes tries with some success to break the monopoly which Egypt has had in this connection. The Sumerian and other Near Eastern sources he discusses have hitherto been little known.

W. Ganzenmüller deals, in German, with some of the future problems in the history of alchemy, particularly bibliographic, and other problems dealing with the literature of the subject.

The story of Meissner porcelain is told, in German, by Wilhelm Prandtl.

A biography of Robert Boyle which was projected but never published was mentioned in a letter found in the Pierpont Morgan Library. The letter is reproduced and commented upon in a chapter by Curt F. Bühler.

A final chapter by Glenn Sonnedecker gives a picture of chemistry teaching in the pharmacy schools of the nineteenth century.

NORRIS W. RAKESTRAW

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● ORGANIC CRYSTALS AND MOLECULES: THEORY OF X-RAY STRUCTURE ANALYSIS WITH APPLICATIONS TO ORGANIC CHEMISTRY

J. Monteath Robertson, Gardiner Professor of Chemistry in the University of Glasgow, Scotland. Cornell University Press, Ithaca, New York, 1953. xi + 340 pp. 132 figs. 14 tables. 15.5 × 24 cm. $5.

THE author of this book is a renowned authority on the analysis of the structures of crystals by means of X-ray diffraction. He has contributed probably more than any other person to the world's knowledge of the precise relative locations of the atoms in organic molecules and crystals.

In Part I he describes the nature of crystals, their symmetry and other geometrical properties, and the methods currently used for determining their structures. The language of crystallographers, often quite unintelligible to others, is simply and lucidly interpreted. Difficulties, such as that of determining the phases of the X-ray reflections, are not glossed over, but explained, and the methods by which they may sometimes be overcome are outlined.

In Part II the results of structure analyses of crystals of organic substances are described. Only a small proportion of the many substances which have been studied are included, but the author has chosen his examples wisely. Among those dealt with are the following: various condensed ring hydrocarbons, hydrogen-bonded structures, steroids, strychnine, penicillin, and fibrous and corpuscular ("globular") proteins. The emphasis throughout is on the significance of the structural results to the noncrystallographic reader.

Each of the two parts of this volume stands on its own feet and could be read or studied with understanding without reference to the other. Both are excellent. The reviewer enthusiastically recommends the book to anyone interested in learning either about modern methods of crystal structure analysis or about the results of such analysis in the field of organic compounds.

MAURICE L. HUGGINS

EASTMAN KODAK COMPANY
ROCHESTER, NEW YORK

GMELIN'S HANDBUCH DER ANORGANISCHEN CHEMIE. SYSTEM 9: SCHWEFEL. PARTS A2 AND B1

Edited by *Erich Pietsch.* Verlag Chemie, GMBH, Weinheim, Germany, 1953. Eighth edition. Part A2, ix + 450 pp. 76 graphs. 17.5 × 25.5 cm. $35.30. Part B1, xi + 372 pp. 75 graphs. 17.5 × 25.5 cm. $29.40. (Available through Walter J. Johnson, Inc., 125 E. 23rd St., New York 10, N. Y.)

THE complete revision of Gmelin's classical handbook of inorganic chemistry, the eighth edition of which began to appear in 1922, is making progress and is expected to be completed some time within the next ten or twelve years, under the present editorship-in-chief of Dr. E. H. E. Pietsch. The guiding principle continues to be the maintenance of the reference character of the work, with critical evaluation of the entire available material, in all but exceptional cases based upon the original literature versions. As usual, chief emphasis is placed upon currently accepted knowledge, and older works are covered only in condensed fashion. Coverage is sufficiently inclusive so that this reference work is a valuable source of information not alone to the chemist, but frequently to those engaged in related fields, such as physics, metallurgy, geology, and mineralogy.

The practice of extending the period of coverage of the literature up to January, 1950, is continued in these issues, and it is the intention to apply this restriction to all subsequent volumes of the eighth edition.

Part A2 of these volumes on sulfur deals with the occurrence and the technology of sulfur and certain of its compounds, with colloidal sulfur, and with the harmful physiological effects of some sulfur compounds.

Inasmuch as in a given volume of Gmelin the coverage includes all combinations of the element concerned with those with lower system numbers, these two sections of System 9 deal only with the combinations of sulfur with elements of Systems 1–8. Accordingly, in addition to elementary sulfur, Part A2 treats of the hydrides and oxides of sulfur, with sulfuric and chlorosulfonic acids.

The geochemistry of sulfur is thoroughly discussed in the first 200 pages of the volume; the remainder of the book is chiefly devoted to the technological aspects of elementary sulfur, hydrogen sulfide, sulfur dioxide and trioxide, and sulfuric acid, with a brief account of chlorosulfonic acid. The instructive account of the preparation of sulfuric acid alone covers more than 160 pages, including not only the pertinent underlying physicochemical principles, but also full details of the industrial methods currently employed.

Part B1 of System 9 deals with the hydrides and oxides of sulfur. The first 155 pages are concerned with a detailed account of hydrogen sulfide: its formation and decomposition and the physical and chemical properties of the gas and of its aqueous and nonaqueous solutions, followed by deuterium sulfide and hydrosulfide and the polysulfides of hydrogen. The oxides of sulfur, including SO, S_2O_3, extensive accounts of SO_2 and of SO_3, and S_2O_7 and SO_4 complete the volume. This account includes a summary of the combustion reactions of sulfur and of the homogeneous gas equilibria of the sulfur-oxygen system. Treatment of SO_2 includes its behavior as a solvent and a discussion of its nonaqueous solutions, as well as its reactions with various metals and other reducing agents. The chapter on SO_3 covers its formation and preparation in a variety of ways; a detailed description of its physical properties, and of its chemical reactions with nonmetals, metals, and the compounds of nonmetals (water, ammonia, hydrazine, oxides of nitrogen, hydrogen halides, etc.), as well as the compounds of metals (metal oxides, nitrates, halides, etc.); and the nonaqueous solutions of SO_3, as well as the solvent properties of liquid SO_3.

The completion of Part B of the sulfur volume, covering the remaining compounds of sulfur, is expected to be accomplished in 1954. There will thus be provided a thoroughgoing and reliable, clear and systematic account of the chemistry of this important element, which will form a welcome addition to the already imposing eighth edition of the Gmelin Handbuch.

WALTER C. SCHUMB

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CRYSTAL STRUCTURES. SECTION III AND SUPPLEMENT II

Ralph W. G. Wyckoff, Laboratory of Physical Biology, National Institute of Arthritis and Metabolic Diseases, Bethesda, Maryland. Interscience Publishers, Inc., New York, 1953. 128 pp. 83 figs. 128 tables. 21 × 26 cm. $14.50 with binder. (With second supplement to Chapter XIII. 15 pp. 28 figs. 30 tables. $4.)

THE third volume of "Crystal Structures" is now available, together with a supplement to Chapter XIII on the structures of aliphatic compounds. Volume III contains Chapter XIV, the Structure of Benzene Derivatives, and Chapter XV, Alicyclic and Heterocyclic Compounds and Carbohydrates.

The Structure Reports, which at present cover the years 1947 to 1949, are the only other volumes containing descriptions of crystal structures which have been determined since 1939. The publication of these volumes of "Crystal Structures" should represent a valuable addition to the literature. It is unfortunate, therefore, that this book is so difficult to read. In each chapter the material is grouped into text, tables, illustrations, and bibliography, and each group is paged separately.

Thus, in Chapter XIV, for *p*-aminophenol, the substance is listed on table page 6; there is a description and discussion of the crystal structure on text pages 59 and 60; there are illustrations of the structure on illustration pages 60 and 61; and finally there is a reference to the literature on bibliography page 20. So to obtain a description of the crystal structure it is necessary to refer to four different parts of the book.

The description of complete structure determinations contains no account of the way in which the final atomic parameters were obtained, and it is therefore difficult to assess the accuracy of these parameters. This is an unfortunate omission, since different methods can yield results of greatly differing accuracy. The drawings accompanying complete determinations are of excellent quality and show very clearly the packing arrangements of the molecules in the crystal.

The way in which substances are listed in the tables makes it easier to locate specific substances than before. But those who use the book will be pleased to know that an index is being prepared and will be published soon.

DAVID R. DAVIES

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TECHNIQUE OF ORGANIC CHEMISTRY. VOLUME VIII: INVESTIGATION OF RATES AND MECHANISMS OF REACTIONS

Edited by *S. L. Friess* and *Arnold Weissberger*. Interscience Publishers, Inc., New York, 1953. xxiii + 760 pp. Many figs. and tables. 16 × 23.5 cm. $12.50.

THE rates and the mechanisms of chemical reactions cannot be predicted by theoretical calculations at present or in the foreseeable future. The challenging problems of chemical kinetics at present are the development of methods that will give deeper and more detailed insights into reaction mechanisms and the accumulation and correlation of reliable empirical information about the effect of structure on reactivity. The volume under review is a refreshing and welcome addition to the literature of chemical kinetics because it gives due consideration to problems of method.

The most concise way to indicate the variety of subjects considered is to enumerate the chapter headings: I, General Theory of Rate Processes; II, Fundamental Operations and Measurements in Obtaining Rate Data; III, Special Experimental Methods for Determination of Rate Data; IV, Evaluation and Interpretation of Rate Data; V, Homogeneous Gas Phase Reactions; VI, Reactions in the Liquid Phase; VII, Homogeneous Catalysis in Solution; VIII, Polymerization and Polymer Reactions; IX, Biological Reactions; X, Rapid Reactions. Each chapter is written by one or a group of specialists. Chapter VI is a very extensive, almost encyclopedic, discussion of liquid phase organic reactions. In the discussion of other topics, such as the use of isotopes in investigating reaction mechanisms (III) or the kinetics of biological reactions (IX), selected examples of the subject are considered. The discussion of such special methods as the use of stirred constant-flow reactors and the use of chopped light experiments for the measurement of the lifetime of a chain carrier in a chain reaction are particularly welcome. Chapter X is an extensive and detailed discussion of fast mixing methods of measuring rapid reactions in solution.

The book contains a wealth of information about the methods of chemical kinetics and about the results of investigations of particular reactions that is otherwise available only in the original literature. It will be useful as a reference work, for a course in chemical kinetics, for active research men, and for chemistry teachers who want a general treatment of the subject.

NORMAN DAVIDSON

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GLYCEROL

A. C. S. Monograph No. 117. Edited by *Carl S. Miner*, Director, The Miner Laboratories, Chicago, Illinois, and *N. N. Dalton*, Research Consultant, Glycerine Producers' Association, New York (retired). Reinhold Publishing Corp., 1953. xiv + 460 pp. Many figs. and tables. 16 × 24 cm. $12.

IN THE words of the authors, this book is "not designed to serve as an operator's manual, but rather to give helpful information to those who require a general knowledge of the subject." Operational details are not excluded but are described in two chapters, "Methods of production" and "Recovery and refining," written by Truman M. Godfrey, consulting chemical engineer, who also furnished the chapter on "Natural source and occurrence." The greater part of the book was written by J. B. Segur of the Miner Laboratories whose contributions cover "Standards and specifications," "Analysis," "Physical properties," "Chemical properties," and "Uses." C. H. Werkman of Iowa State College contributed a short chapter on "The biochemical use of glycerol" and Martin E. Hanke of the University of Chicago one on the "Physiological action of glycerol." These chapter headings, plus that of the first chapter, "History and economics," provided by N. N. Dalton and Joyce C. Kern of the Glycerine Producers' Association, indicate rather well the scope of the book.

The authors have kept well in mind the diverse interests and proficiencies of their readers. This is a book which can be read with interest by a student in his first course in organic chemistry and by his instructor who may seek to extend his knowledge of glycerol and its compounds. The extensive chapter on analysis contains a collection of new and old methods which would be valuable to those having either frequent or occasional need for this information. Both qualitative and quantitative analyses are described. Interferences and limits of accuracy are indicated. The chapter "Uses of glycerine" is intended to show the breadth of application of this compound. Detailed instructions for such uses are, in general, omitted. A worker seeking such instructions will need to consult handbooks of formulas for details.

Only occasionally is a word used without adequate explanation. A reader who is unfamiliar with the term may be perplexed at finding (page 31) "titer" expressed in degrees Centigrade. He may be unfamiliar with the term "raffinate" (page 38) used in extraction. Other terms which seem inadequately defined are "fitting" (page 43), "niger" (page 43), and "flash" (page 40). This latter term may carry more meaning after the reader has finished pages 53 and 112. This portion of the book appears to be intended for the specialist, who may be assumed to be familiar with the terminology.

The book is well printed and arranged. It is provided with a six-page table of contents and a ten-page index. By their use it is possible to turn quickly to any topic discussed in the book. The authors are to be complimented on this accomplishment. The text is liberally provided with tables of properties, diagrams of equipment, and charts. Considerable effort seems to have been made to place figures and tables so that they can be readily consulted while one is reading the accompanying text. Literature references are plentiful. An attempt is made to give the source of all information, the only exception being that of certain charts dealing with production and consumption. Eight hundred sixty-five references to the literature are given in about 430 pages of text. This is a book which is likely to be read in its entirety if it is consulted for a specific item of information.

ERNEST R. KLINE

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ORGANIC ANALYSIS. VOLUME I

Edited by *J. Mitchell, Jr., I. M. Kolthoff, E. S. Proskauer*, and *A. Weissberger*. Interscience Publishers, Inc., New York, 1953. viii + 480 pp. 68 figs. 113 tables. 15.5 × 23.5 cm. $8.50.

THE editors and publishers of "Organic Analysis" have undertaken a highly useful, long-range program in which they plan to "...treat the entire field of organic analysis in the form of collective volumes." The first few of these volumes, which are scheduled for annual publication, will deal with functional group analysis, with particular attention to the more recent developments in the field. This sizable task has been initiated with the present volume, made up of nine chapters written by authorities on the topics covered. Five chapters are devoted to *oxy* and *oxo* compounds (hydroxy, alkoxy, alpha-epoxy, carbonyl, and acetal), two chapters to the determination of active hydrogen (using organometallic compounds and diazomethane), one chapter to organic sulfur compounds, and one chapter to spectrographic functional group analysis.

Although, in the words of the editors, the "...series 'Organic Analysis' is designed...to consolidate current knowledge, and to evaluate critically the many procedures employed," the whole of the present volume unfortunately does not fulfill this aim. Parts of the volume can only be characterized as an uninspired record of the literature, lacking both clarity of presentation and critical evaluation. It is difficult in collective works to maintain

a level of excellence throughout, but more careful editing of future volumes in this series would detect such phrases as "the equilibrium being shifted toward completion by the use of a catalyst" and could help to insure the high standards which the editors clearly had planned to maintain.

Any criticism of the present volume is directed at only a portion of the work. Much of it is excellent, and parts of it are unique. The chapter on analysis of organic sulfur compounds (mercaptans, sulfides, disulfides, xanthates, thials, thiones, mercaptals, mercaptols, sulfoxides, sulfinic acids, sulfonic acids, and alkyl sulfates) represents the most complete review of the extensive literature on the determination of sulfur-containing functional groups that has been published. Moreover, for the first time a comprehensive discussion of the analytical significance of diazomethane for determining the presence of active hydrogen and its position in a molecule is presented by the eminent author of most of the original papers. Although an excellent review of the chemistry of α- and β-epoxides was published in 1950, the present very readable chapter on the quantitative determination of the α-epoxy group is a timely contribution. The material is well organized and lucidly presented, and includes unpublished data from the authors' laboratories and a good critical comparison of available methods.

Analytical and organic chemists can be grateful indeed that the authors and editors are planning a comprehensive and critical compilation of the multitudinous techniques in the field of quantitative organic analysis. Each new volume in the series will ease the burden for those whose work requires a knowledge of existing analytical methods.

FRANCES BERLINER

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● ESSENTIALS OF PHYSIOLOGICAL CHEMISTRY

Arthur K. Anderson, Professor of Physiological Chemistry, The Pennsylvania State College. Fourth edition. John Wiley & Sons, Inc., New York, 1953. vii + 480 pp. 42 figs. 12 tables. 15.5 × 23.5 cm. $5.

A great many undergraduate students intending to enter general chemistry, agriculture, bacteriology, premedicine, home economics, or related fields need some understanding of biochemical principles. Their requirements are not as exacting and thoroughgoing as those of more advanced students and a brief, elementary text is really needed for them. This is the purpose of Dr. Anderson's text, now in its fourth edition. It will not be found at all suitable for the student requiring critical knowledge of the subject.

The text properly emphasizes the chemical structure of biological compounds and it has been somewhat enlarged and modernized. A new chapter, Biophysical Chemistry, is a welcome addition. The chapters each terminate with a series of rather comprehensive questions which ought to prove useful for review by the beginning student. Reference lists are brief and indicate only the broad general works, an arrangement entirely suitable to the intended audience, who make little use of bibliographies.

The author states in his preface that many of the subjects considered in the book are controversial but that he has purposely avoided presenting arguments pro and con because it seems unwise to confuse the student. While this concern for the student is certainly laudable, the result leaves something to be desired. It seems to the reviewer that no student has any need to be taught theoretical subject matter in a cut-and-dried, plodding way as if it were factual. If this is the only way he can be taught the material, he has no business learning it at all. The reviewer is inclined to the view that an elementary text should confine itself only to those matters which can be adequately covered in the short space permitted. This principle ought be adhered to even at the expense of omitting some subjects. There is no reason to believe that a student will be better off if he is exposed to much material inadequately discussed than he would be on simpler fare more properly digested. Where theoretical biochemistry is presented as if it were entirely factual the resulting picture of the science is a strange one indeed. It presents an emasculated science, a muse with her teeth pulled.

Despite such criticisms the book is a creditable one; it fills a real need and has a place in the teaching of the elements of a complicated field. It will, like previous editions, find wide use in undergraduate courses.

ELIOT F. BEACH

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● ANNUAL REVIEW OF PHYSICAL CHEMISTRY. VOLUME 4

Edited by _G. K. Rollefson_ and _R. E. Powell_. Annual Reviews, Inc., Stanford, California, 1953. 493 pp. 16 × 23 cm. $6.

This fourth volume in the widely acclaimed annual review series begun in 1950 establishes itself as an essential addition to any library used by professors and students trying to keep abreast of current status of, and new trends in, research in physical chemistry. Those familiar with previous volumes will recognize eighteen regulars among the listed topics, one return of an absentee since 1951 ("Microwaves," expanded to include "Nuclear resonance"), and a new title ("Magnetism") written by the man whose name is synonymous with the field, Selwood. "Colloids" is again omitted, but many phases of the subject are inevitably included in the sections on "Contact catalysis and surface chemistry" (omitted in 1952), "High polymers," and "Ion exchange."

In a well established series of volumes of this type, it is appropriate that the authors chosen for each section should be new contributors. This policy results in a valuable variety of emphases over the years. The limitations are in most cases frankly stated and make most of the treatments accorded to various topics more authoritative and refreshingly free from being mere superficial listing of bibliographies for broad fields. This is true, for example, in Sutherland's confining his chapter on "Spectroscopy" to discussions of vibrational spectra. Another example lies in the "Reaction kinetics" chapter, in which Taube covers most thoroughly the topics of oxidation-reduction reactions and the kinetics of substitution at metal ion centers. The same is true of the chapter by Lumry, Spikes, and Eyring on "Photosynthesis," in which they choose to discuss pigments, energy transfer mechanisms, and the Hill reaction rather than to repeat the Calvin, _et al._, (1952) emphasis on carbon dioxide fixation and quantum yield arguments.

As has been true of previous volumes in the series, the majority of the contributors are from American academic institutions or industrial laboratories. The inclusion of the British authorities Weiss on "Radiation chemistry" and Lennard-Jones on the "Theory of molecular structure" is most welcome. Canadian institutions are the base of operations for the authors of two other chapters, Thode on "Isotopes" and Steacie, _et al._, on "Photochemistry."

The twenty chapters are based on reviews of the current literature concluded in the late months of 1952. The lists of references cited run into the hundreds for each topic. This fact further emphasizes the value of the volume as an authoritative, critical compilation. Some tables of numerical data are presented. There are relatively few diagrams; almost no discussion is devoted to apparatus or methods of measurement. A complete author index and an extensive subject index add to the usefulness of the book.

WILLIAM F. KIEFFER

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• PRACTICAL CHROMATOGRAPHY

Robert C. Brimley and *Frederick C. Barrett*, Low Temperature Research Station, Cambridge, England. Reinhold Publishing Corp., New York, 1953. 128 pp. 34 figs. 14 × 22.5 cm. $5.

IN THE introduction the authors state: "It is hoped that the general student and workers who come new to the subject with a practical problem, will have sufficient detail before them to judge what may be attained by the use of chromatographic methods." This little book does provide a quick glance at some of the separations which have been accomplished by means of chromatography, and for the reader "new to the subject" should provide an interesting evening's reading. Much of it is written in the past tense, it being an historical narration of selected individual experiments, by past and present chromatographers, which have now come to be regarded as more or less classical. Only 93 pages are actually devoted to chromatography, which has been subdivided into paper and column methods, involving adsorption, partition, and ion exchange. Applications are concerned chiefly with amino acids, sugars, and certain organic acids.

Pertinent details are frequently lacking, the authors lapsing into vague generalities such as "any suitable solvent" or "certain other factors." Description of involved techniques is repeatedly sidestepped with the statement that they are "not simple." One is left with the impression that Whatman filter paper is the only brand which can be used for paper chromatography. There are only 113 references; by way of contrast, Strain published 420 references in a single journal article on chromatography (*Anal. Chem.*, **23**, 25 (1951)). Historically, one might wish that the authors had mentioned the work of W. G. Brown of the University of Chicago, whose description of true paper chromatography (*Nature*, **143**, 377 (1939)), as distinguished from capillary analysis, antedated the publication of Consden, Gordon, and Martin by five years.

A better editing job would have corrected the frequent grammatical and typographical errors, and might have improved the rather awkward organization and frequently abstruse exposition. A much larger volume would be required for adequate treatment of the subject. As a whole, the book is somewhat of a disappointment. Perhaps too much was expected due to its origin in the Low Temperature Station at Cambridge University, England, whose staff includes several scientists of very outstanding repute in the various fields of chromatography.

A. R. PATTON

COLORADO A & M COLLEGE
FORT COLLINS, COLORADO

• GENERAL COLLEGE CHEMISTRY

Frank Brescia, Assistant Professor of Chemistry, The City College of New York. The Blakiston Company, Inc., New York, 1953. ix + 581 pp. 125 figs. 65 tables. 15 × 23 cm. $6.

IN THE words of the author, "This text is intended for first year college science and engineering students; it possesses, therefore, a rather mature point of view." As the above implies, this book is a challenge to the best efforts of the most capable students. It is a well ordered, scholarly presentation of modern chemical theory. The "Text material, rather fully documented, to show that our present knowledge is the culmination of the labors of many men, has been separated into 30 chapters. Much useful and further explanatory material is attached as an appendix to several chapters from which teacher and student may draw as they see fit."

Fundamental principles are clearly and more completely developed than is usual, with the student's being asked to accept much less on faith than is frequently true. Some of the dogma is stripped from the scientific method and its usefulness and its limitations are frankly stated.

Principles are frequently illustrated with data from the work of the person who is usually given credit for their discovery or elucidation. Thus much of the history of chemistry is included without distraction and with practically no extra space consumed.

Despite the author's statement that "This text is not a 'diluted' course in physical chemistry," a larger proportion of space than usual is given to physical principles and less to descriptive inorganic chemistry. One need not quarrel with this procedure so long as the fact is recognized and provision made elsewhere in the curriculum for the material omitted which is usually considered a part of the chemist's equipment.

Each chapter is concluded with an unusually good set of exercises which are thought-provoking and will test the capacity of the best students. The exercises are numerous and within any given list they increase in difficulty. Much thought and imagination has gone into their selection and they represent one of the most valuable features of the book.

The binding and paper stock are good. The type is smaller and the lines set closer together than desirable for easy reading, but it is only by this device that the material of the book has been compressed to 527 pages exclusive of appendixes and indexes.

The illustrations are line drawings, for the most part, with occasional photographs. Many are good, but the cell system, Figure 100, page 374, as well as those of several other electrochemical cells, are confusing and require considerable study to grasp the ideas they are meant to convey. Many better illustrations of the blast furnace and open hearth furnace are readily available. A large number of graphs have been used to illustrate variations in properties with conditions.

The author is to be congratulated particularly for his clear explanations and development of chemical theory and for the unusually original and thought-provoking series of exercises at the end of each chapter. Those instructors who have carefully selected groups of more capable students should welcome this text as a real challenge. It has much to offer the teacher of any beginning chemistry course.

FREDERIC B. DUTTON

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• ORGANIC SYNTHESES. VOLUME 33

Charles C. Price, Editor-in-Chief. John Wiley & Sons, Inc., New York, 1953. vi + 115 pp. 15.5 × 23.5 cm. $3.50.

THIS latest addition to a well established series brings together the work of 64 contributors treating 40 new syntheses. Volume 33, like the previous volumes, presents the most convenient methods for preparing a variety of organic chemical reagents. All the reactions discussed have been checked by leading chemists throughout the country. This volume again gives the equations for the reactions, procedures for production with accompanying notes, and other methods of preparation. An interesting and important insert calls attention to the hazardous nature of a compound listed previously and states that "The sodium salt of nitromalonaldehyde [*Org. Syntheses*, **32**, 95 (1952)] is impact-sensitive and thermally unstable and should be handled as a potentially explosive material." All users of these volumes will, therefore, want to make the corresponding notation on page 95 of Volume 32.

Preparations are listed under common names and *Chemical Abstract* indexing names for: 3-acetamido-2-butanone, alloxantin dihydrate, atrolactic acid, benzhydryl-β-chloroethyl ether, benzoguanamine, butyrchloral, creosol, di-tert-butyl malonate, diethyl-1,1-cyclobutane dicarboxylate, diethyl-γ-oxopimelate, *p*-dimethylaminobenzaldehyde, dimethylketene, 2,2-dimethylpyrrolidine, ethyl-α-(1-pyrrolidyl)-propionate, 9-fluorenecarboxylic acid, furfural diacetate, itaconyl chloride, 3-methylcoumarone, 1,5-naphthalenedithiol, 1,4-naphthoquinone, nicotinonitrile, *m*-nitrobenzazide, *m*-nitrobiphenyl, *o*-nitrocinnamaldehyde, *m*-nitrostyrene, 6-nitroveratraldehyde, 4-pentyn-1-ol, α-phenylcinnamic acid, 4-phenyl-*m*-dioxane, *o*-phenylene car-

bonate, 3-phenyl-1-propanol, pyridine-N-oxide, 2-(1-pyrrolidyl)-propanol, stearone, *cis*-stilbene, α-tetralone, 3-thenaldehyde, 3-thenoic acid, 3-thenyl bromide, and α,β,β-triphenylpropionic acid.

The cumulative subject index comprises all material contained in Volumes 30 to 33 inclusive, all previous preparations having been tabulated in Collective Volumes I and II and Volume 29. This volume again conforms completely in size, style, appearance, and quality with all previous releases in the series. It is significant to note that over 1000 preparations have now appeared in these useful and unique volumes, and each succeeding number adds materially to the comprehensiveness, total coverage, and value of the series. They can now be regarded, not only as an indispensable series of annual volumes, but as an imposing and essential institution in the realm of organic chemistry. This latest addition will again rate a *must* on the book list of every progressive organic chemist and purchaser of previous volumes of the series.

RALPH E. DUNBAR

North Dakota State College
Fargo, North Dakota

● FUNDAMENTALS OF CHEMISTRY

L. Jean Bogert, **formerly Instructor in Medicine, The University of Chicago, Instructor in Experimental Medicine, The Yale Medical School, and Lecturer in Chemistry, Connecticut Training-School for Nurses. W. B. Saunders Co., Philadelphia, 1953. Seventh edition. xx + 648 pp. 168 figs. 14 × 20.5 cm. $4.50.**

The fact that Professor Bogert's book is now in its seventh edition testifies to its popularity. It is, as the title indicates, a book dedicated to what the author considers fundamentals. The material included adequately covers the field of general chemistry but it will be considered by many as lacking in certain areas. Throughout the book there is a dearth of the mathematical applications of chemical principles which one might expect. In spite of the present-day emphasis on atomic, molecular, and crystalline structure studies comparatively little is offered to introduce the students to this vast field. The exercises at the end of each chapter tend to be fact-searching rather than thought-provoking. The book would seem to be best suited to courses for students who are interested only in a cursory knowledge of the general field of chemistry.

From the teacher's viewpoint it would be a pleasure to use this book. Some of the most interesting areas of chemistry are presented and the book is lavishly illustrated. Those areas of chemistry which are of a more disciplinary nature are not accentuated. Professor Bogert's book should continue to fill the need in the chemistry curriculum for a course for students in the liberal-arts curriculum, for home economics students, and for students preparing for the nursing profession.

SISTER MARY MARTINETTE, B.V.M.

Mundelein College for Women
Chicago, Illinois

● MAN AND THE CHEMICAL ELEMENTS

J. Newton Friend, **formerly head of chemistry department, Technical College, Birmingham, England. Charles Griffin & Co., Ltd., London, 1951. x + 354 pp. 4 plates. 14 figs. 16.5 × 25.5 cm. 27*s.* 6*d.***

This book is an extension of a series of articles on "The Historical and Industrial Discovery of the Elements" written by the author over the last ten years. The theme of the present work is the story of when and how the chemical elements were discovered in relation to the history of chemistry as a whole. In some 23 chapters the author covers the elements from the inert gases to the radio elements and the actinide series, with the material concerned arranged as groups or subgroups of the periodic table. Although this mode of presentation is commendable for demonstrating the interrelationships of the individually discovered elements, it does lead to a distortion of the historical sequence and is in some instances repetitious.

The book is directed to the general reader and students of chemistry, not historians of science, and from this point has much of value, for it does tell an interesting story. Throughout, the author has interpolated industrial usage and processes, but these are too brief to instruct the reader and lead in fact to confusion. It does, however, cover the discovery of the elements from the Stone Age to the present with ample attention to the developments ushered in with the atomic age. Many anecdotes, usually absent from a conventional scholarly treatment, attest to the author's humanism and humor. There are some misprints, incorrect statements, and a lack of early sources, but these are minor and are principally the concern of the historian.

A subject and name index facilitates the use of the work. The publishers are justified in claiming that the book may "be read with profit by the student, with interest by the chemist, and with enjoyment by all."

HERBERT S. KLICKSTEIN

University of Pennsylvania
Philadelphia, Pennsylvania

● THE FURANS

A. P. Dunlop, **Assistant Director, Chemical Research, and *F. N. Peters,* Vice-President, The Quaker Oats Company. American Chemical Society Monograph Series. Reinhold Publishing Corp., New York, 1953. xix + 867 pp. 9 figs. 148 tables. 16 × 23.5 cm. $18.**

This monograph was written by two men who have been assoicated with developments in the field of furan chemistry for many years.

Chemical industry early recognized the need for a complete review of furfural and in the thirties one of the authors of the present monograph, Dr. Peters, began to prepare such a review. The project was dropped and was revived in 1947 with the cooperation of Dr. Dunlop. By this time furan chemistry had developed to such an extent that it became imperative that any review, to be of value at all, include all furan compounds. This monograph is the result of the efforts of Drs. Dunlop and Peters and covers references to the literature to December, 1950.

The text is divided into two parts. In Part One, which represents about seven-eighths of the book, the authors have covered the common types of furan derivatives. In this part there are excellent chapters on the physical chemistry of the furan nucleus; analytical methods for furfural and the physical and chemical properties of this compound; and catalytic hydrogenation of furan (contributed by S. Swadesh). Other chapters deal with the chemistry of further furan derivatives. Part Two covers applications of furfural and its derivatives.

It might be stated with assurance that no other heterocycle has received the painstaking review that has been granted these commercially important compounds. There are by rapid count over four thousand references in the text and many of these references are multiple citations. In addition there are about 2000 references to furan resin patents.

The print maintains the usual high standard of excellence of the monograph series. The index is adequate and is printed in both light and boldface type which makes for quick and easy reference.

The authors and all who aided in the production of this work are to be congratulated.

LIONEL JOSEPH

San Diego State College
San Diego, California

Out of the Editor's Basket

New Chelating Agent for Trivalent Iron

"Versen-OL" is the name of the new product which should have wide application in wet processing wherever trace iron creates a problem and causes trouble through its contaminating influence. Known chemically as the trisodium salt of N-hydroxyethylethylene diamine triacetic acid, the new compound is extremely soluble in water and highly stable throughout the pH range.

Through Versen-OL it is now possible to control trivalent iron over a wide pH range. It forms strong 1:1 ferric chelates and prevents hydrolytic decomposition; even in strongly alkaline solutions. Any Versen-OL that remains after chelating the iron present will then inactivate other heavy metal or alkaline earth ions until exhausted. This is indeed good news for processors of paper, textiles, soaps, and other materials in which trace iron is involved.

Versen-OL, discovered and developed by Bersworth, is the newest of the "Versenes." It is manufactured by The Bersworth Chemical Company in Framingham, Mass. Patents on the new product are already pending and it is now available in commercial quantities. Research samples may be had on request by writing direct to the manufacturer.

Glassware Washing at University Laboratory

A wholly unexpected advantage is revealed in the reported results received by a large midwestern university from its use of the new C.R.C. Labwasher. This unforseen advantage lies in the apparent elimination of the necessity for the distilled water rinsing of laboratory glassware following its washing. This new benefit has since been confirmed by a major oil company and other users who were among the early buyers of the Labwasher in October.

It develops that due to the quick drainage of the glassware in the Labwasher; plus the unusual wetting action of the specially-compounded detergent; laboratory glassware washed in the Labwasher retains less than one part per million of ionized salts from ordinary tap water. Thus the machine which was developed to take away the drudgery of handwashing and hand drying laboratory glassware, is demonstrating its broader-than-expected utility.

The Labwasher was developed through the combined efforts of The Chemical Rubber Co., and the Westinghouse Corporation. Further details may be had by writing Chemical Rubber Co., 2310 Superior Ave., Cleveland, Ohio.

Nuclear-Chicago Absorber Set

A packaged set of radioactivity absorbers, consisting of 24 lead and aluminum discs mounted in uniform plastic rings, is announced by the Nuclear Instrument and Chemical Corp., 229 W. Erie St., Chicago 10, Illinois. The Model C-101 absorber set is used with a Geiger tube mount and a scaler or count-rate meter to determine the energies of photons and beta radiations, check isotope purity, identify radioactive species, study decay schemes, or to count a radioisotope in the presence of another.

Activity readings are taken with various absorbers placed between the Geiger counter and the radioactive source. Successively heavier absorbers are positioned one at a time over the radioactive sample until there is no longer any measured activity. In this manner, a characteristic absorption curve is obtained for the isotope in question.

The absorbers are $1^7/_8$ inch in diameter and $^3/_{16}$ inch thick. Each absorber is individually calibrated and the complete set is housed in a handsome walnut case. Their weight ranges from 1.7 mg./cm.^{2} to 6720 mg./cm.^{2}

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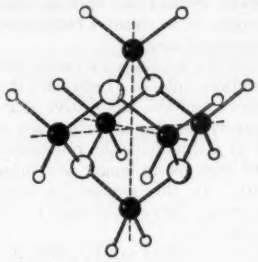

ORGANIC CRYSTALS AND MOLECULES: Theory of X-Ray Applications to Organic Chemistry. By J. Monteath Robertson, The University of Glasgow.

The most recent and powerful methods of X-ray analysis are described in detail in this book, the first to be devoted primarily to the application of X-ray methods to the problems of organic chemistry. Many diagrams were especially prepared for this book.

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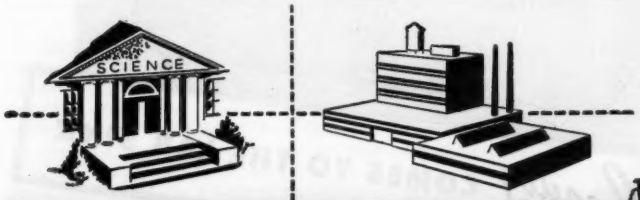

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The company describes the apparatus as a top drive type, equipped with a universal heavy-duty motor linked with a built-in variable transformer. A rate adjustment knob permits fingertip speed control anywhere from 100 to 27,000 r. p. m.

Specially designed fluted homogenizing flasks along with razor sharp 18–8 stainless steel cutting blades reduce homogenizing time to as little as 15 seconds.

Complete information regarding this new versatile homogenizer and its many accessories is available on request from E. Machlett & Son, 220 E. 23rd St., New York 10, New York.

Timers for Counting Systems

The Atomic Center for Instruments & Equipment, Inc., 489 Fifth Ave., New York 17, New York, features two new electric timer models engineered particularly for precise measurement of elapsed time in conjunction with radioactivity counting systems. The timers have ranges from 0.1 second to 10,000 seconds, and 0.01 minute to 1000 minutes read on an odometer-type clock. The timers are driven by a synchronous electric motor requiring no oiling. Starting and stopping losses are self-compensating. The timers can be reset to zero by one turn of a resetting knob. The units are housed in a compact cast aluminum dust-protecting case finished in a gray baked enamel, which lends itself to easy decontamination.

Improved Pyrex Brand Stopcocks

An improved line of Pyrex brand stopcocks at no increase in price, and featuring a new spring type clamp, was announced this month by the Laboratory and Pharmaceutical Sales Department of Corning Glass Works.

Standard on the entire line, the spring type clamp replaces the old style rubber washer formerly used, and improves stopcock performance by further reducing the possibility of leakage. With the new retainer spring, tension remains positive longer, and minor adjustments may be made as required.

The clamp snaps readily into the groove in the end of the stopcock plug and prevents its working loose by maintaining a constant pressure against the shell. The stoppers will neither work loose nor fall out regardless of the angle or position in which they are used.

The new retainer spring also minimizes the danger of freezing, which is usually caused by too much pressure being exerted on the stopcock plug. With the new spring there is no need to apply force. The constant thrust is firm enough to seal the stopper without causing excess loss of stopcock lubricant or otherwise impairing normal stopcock functioning.

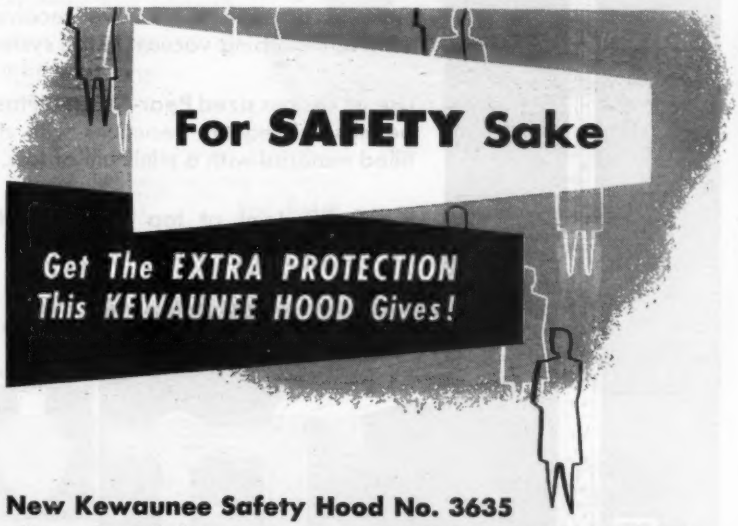
The new retainer spring is designed to fit all Pyrex brand stopcocks and the new assemblies are already equipped with it. Extra retainers in a variety of sizes may be purchased from the dealer who supplies you with Pyrex brand laboratory glassware.

Waste Recovery

Dr. B. C. Hendricks of Longview, Washington, sent us recently an account of an interesting project in the recovery of waste products.

It has long been the practice in the paper industry to let the spent pulp liquors go to waste. Among the pulp plants in the northwest this was done by dumping them into the ocean or Sound, but as the plants have moved up the rivers this has become impractical. Not only from the standpoint of pollution but also in the interest of economic recovery many of these factories have recently adopted a combustion method of disposing of this material.

Lignin of the wood is normally dissolved by calcium bisulfite. The latter material is produced by running sulfur dioxide gas into a suspension of lime. Since about one half of the original wood remains dissolved in the spent liquors a considerable potential of fuel is wasted. By the combustion method now being used 80 per cent of the original sulfite can be recovered, with the possibility of even further savings. The liquors are evaporated to a content of 60 per cent solids, sprayed into recovery boilers and evaporated and burned in a restricted air supply. Since magnesium bisulfite decomposes more easily and effectively under these circumstances than the



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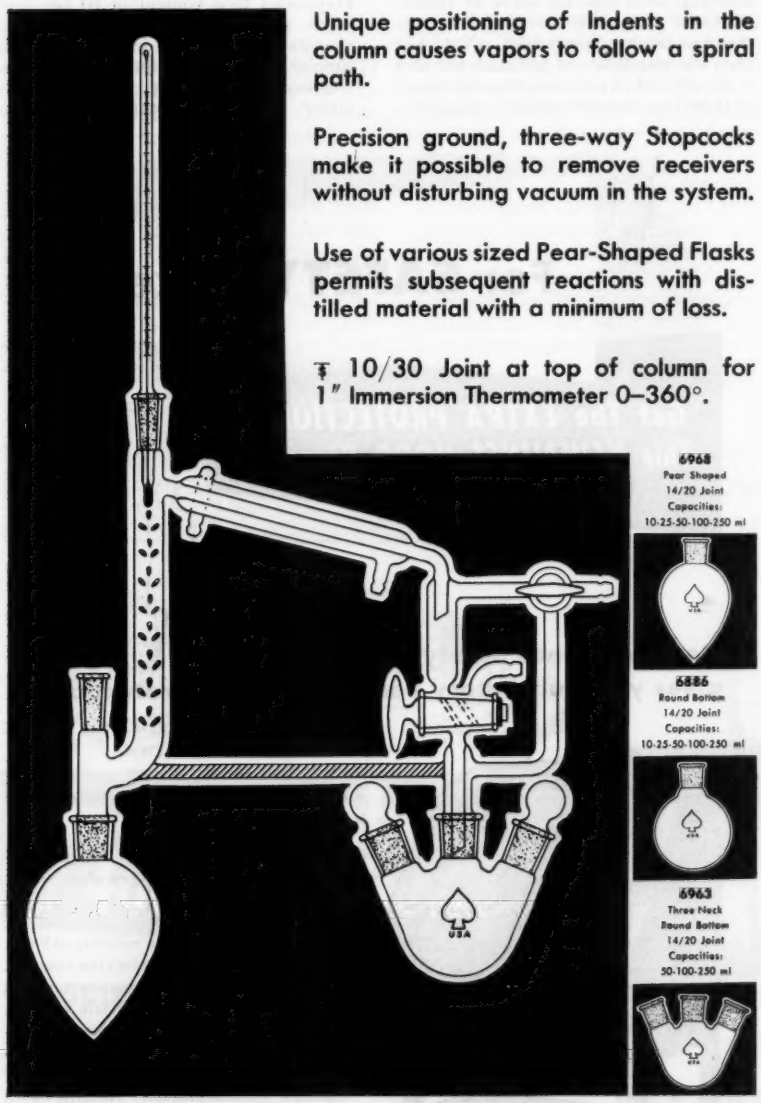

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calcium compound, magnesium hydroxide is substituted for calcium oxide in the initial stages. To prepare the magnesia, calcined dolomite (a combination of magnesium and calcium carbonates) is added to sea water. The calcium oxide reacts with the magnesium chloride in the water to precipitate magnesia. All this is an interesting combination of chemical reactions, both to save waste loss and to reduce a pollution hazard.

New Stone Grinding Mill

A 1/4-h.p. electric stone grinding mill for grinding tough, fibrous organic materials, such as cereals, drugs, spices, certain plastics, and molding compounds has been included in the wide range of mills being manufactured by the Lee Engineering Company, 2023 W. Wisconsin Ave., Milwaukee 3, Wisconsin.

The mill is adjustable to nine degrees of fineness, from coarse particle size down to finest flour. The material to be ground is centrifugally forced against a stationary abrasive ring of special hardness. An automatic governor permits the exact amount of material to be fed into the grinding chamber to assure efficient grinding. The material is ground to uniform mesh, eliminating the operation of sifting or bolting.

Ventilation of the grinding chamber prevents any heat to develop that may effect the material being ground. The chamber has a simple clean-out.

Capacity depends on the nature of the material to be ground. When grinding wheat into flour the mill has a capacity of 8 to 10 pounds an hour. Coarse particle sizes are ground in much shorter time.

New "Plan-A-Lab" Folder

A transparent plastic guide rule and template corresponding to the 1/4 in. to 1 ft. scale, with rectangular cutouts representing various base units are provided in this new planning kit which assists chemical laboratories, school research departments, architects, and engineers in planning their modular layout is now available from this company.

Illustrated on page 2 is a compactly designed floor showing all types of bases that would layout properly. An explanatory chart is shown on page 3, which states the types of units that are above and below the table tops.

The back page lists and illustrates service symbols and letters. In addition, Metalab's recommendations of color schemes, floor coverings, and illumination are described. Specially designed graph paper is inserted. This paper is 1/4 in. to 1 ft., to assist you in using the "Plan-A-Lab" folder.

Research directors, chemists, school, and hospital department heads will receive this important Planning Guide by writing on their letterhead to Metalab Equipment Corp., 224 Duffy Ave., Hicksville, L.I., New York.

Antibumping Agent

Moddie D. Taylor and Louis R. Grant of Howard University, Washington, D. C., have suggested the use of scrap platinum (cuttings or wire) as an antibumping agent. They found that it prevented bumping completely in every case in which it was used over the past four years. Though the initial expense might seem a disadvantage, the ability to use it over and over makes the total expense small.

New Electric Heat Source

A new electric heat source provides controlled heat input for softening-point tests of bituminous materials and makes control of temperature-rise rate easy and certain. It is ideally suited for use in making softening-point tests in accordance with A.S.T.M. Designations D36-26, D61-38, and E28-51, and Federal Specification SS-R-406a.

Current passing through the electric heating unit of the new heat source is indicated by an ammeter on the front panel and adjusted by means of a variable transformer beside the ammeter. Once the proper current setting has been established for the container being used, all future tests can be run by simply setting the current to the proper value. Thus, one of the most difficult features of softening-point tests of bituminous materials—control of the rate of temperature rise—is obviated.

The new Aminco Electric Heat Source has a heatproof, acid-resistant 12-in. square work surface, a built-in laboratory support rod, and a light source for easy visibility of the specimen. No gauze support or asbestos pad is required for the specimen container, which can be placed directly on the heating ring. The heating unit is rated at 500 watts.

Details are given in Bulletin 2246, available from the manufacturer, American Instrument Co., Inc., Silver Spring, Maryland.

New Literature

● Scientific Glass Apparatus Co., Inc., Bloomfield, New Jersey, has just announced the issuance of a new 24-page edition of "What's New for the Laboratory"—19th in the series.

Many new items are featured including a new line of heating mantles with aluminum housings, two new ovens, a sterile fluids pump, Pyrex glass fraction cutter, chromatography equipment, ultraviolet lamps, Coors porcelainware, automatic glassware washer, AO Rapid-Scanning

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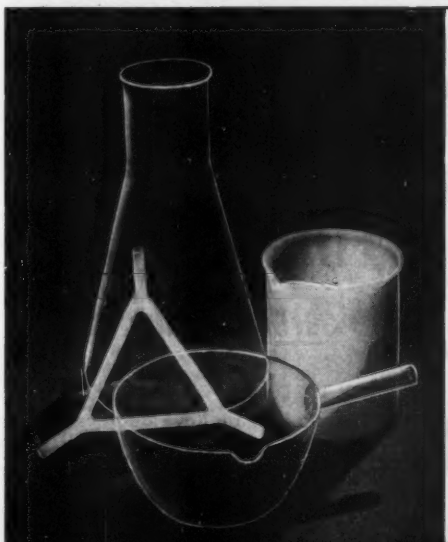

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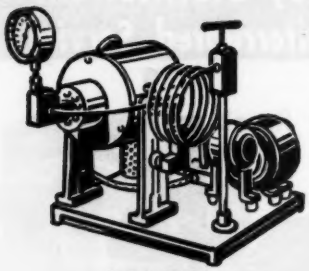

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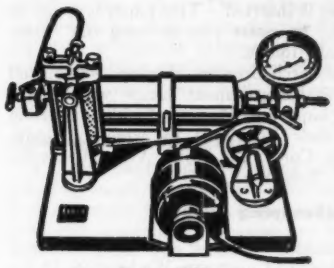

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● The 1954 edition of the booklet, "Physical Properties of Synthetic Organic Chemicals," has just been issued by Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp. This 20-page booklet is issued annually and is a helpful guide for users of organic chemicals. The 1954 edition presents data on more than 330 products and features 36 new chemicals.

For easy reference, the chemicals are arranged by family groups. Condensed data on applications are presented and physical properties are given in tabular form. Copies may be obtained without charge from Carbide and Carbon Chemicals Co., 30 E. 42nd St., New York 17, New York. Write for the "P.P.S.O.C." Booklet F-6136.

● Catalogue No. 15 of Radiation Counter Laboratories, Inc., 5122 W. Grove St., Skokie, Illinois, is a comprehensive, illustrated guide for selection of radiation detection equipment. It is divided into three sections. Section I covers electronic equipment, including scalers, special electronic instruments, and nuclear reactor control equipment. Section II is devoted to radiation counter tubes of all types, scintillation counting equipment, health instruments, and accessories. Section III covers glass apparatus, scintillating crystals and liquids, special chemicals and gases, and thin films.

● Up-to-date data and information on the characteristics of Kodagraph reproduction materials are provided by a new edition of the Eastman Kodak Co.'s publication, "Modern Drawing and Document Reproduction."

New sections on Kodagraph Projection Positive Paper and Kodagraph Microprint Paper have been added to the booklet. The latest data on sheet sizes, roll sizes, and packings have also been incorporated for all products covered.

Designed to provide basic information on Kodak reproduction materials for use in engineering, industrial, and other fields, the booklet is available without charge from Industrial Sales Division, Eastman Kodak Co., Rochester 4, New York.

● Bulletin 650, containing detailed information on small parts storage cabinets, special offering of pressure gauges, several models of timers and stopwatches, small circulating pumps, manometers, and a variety of other laboratory instruments available free upon request from Andrew Technical Service, 6972 N. Clark St., Chicago 26, Ill.

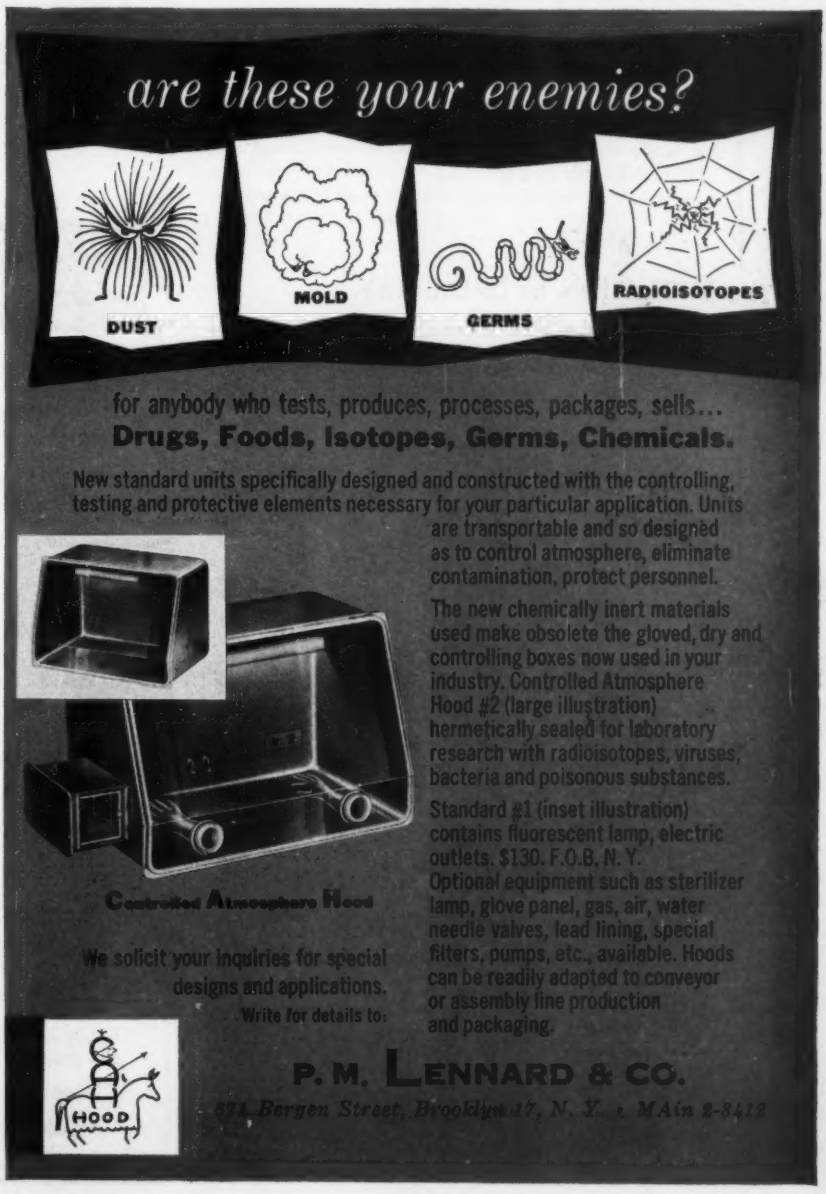
● Mann Research Laboratories, Inc., 136 Liberty Street, New York 6, New York, have published their new price list No. 119 containing 180 more biochemicals than their previous list. The outstanding feature of this new list is the 240 amino acids and derivatives.

In addition to all the L, D, and DL amino acids, are complete listings of Carbobenzoxy amino acids of special interest to the biochemist. Peptides and Polypeptides, Enzymes, Rare Sugars and Research Chemicals complete this new price list.

● A new monthly bulletin describing selected laboratory equipment is now available free. This 8-page, fully illustrated bulletin entitled "Daigger Laboratory Digest" is published by A. Daigger & Co., serving laboratories for more than half a century. It contains a comprehensive listing of laboratory equipment, both foreign and domestic, with a view toward presenting the most advanced instruments and products available at moderate cost. The "Daigger Laboratory Digest" is a handy reference for all users of laboratory equipment including institutions and hospitals, as well as industrial researchers. To receive your monthly bulletin write to: A. Daigger & Company, 159 W. Kinzie Street, Chicago 10, Illinois.

● A catalog has recently been released by M. Ducommun Co., 1 W. 47th St., New York 19, New York, manufacturers of Minerva watches and stopwatches, featuring their full line of Minerva timepieces. This new catalogue includes special stopwatches for industrial, medical, and research purposes, with precision time and motion study features.

● The second supplement to list Number 38 of more than 3500 organic chemicals supplied by the Distillation Products Industries division of the Eastman Kodak Co. has just been announced. The supplement lists 47 additions to the catalogue, showing the name of the chemical, its melting or boiling point, structural formula, molecular weight, and price according to quantity. It also includes removals and price changes. Copies of the supplement may be obtained without charge, by writing to Eastman Organic Chemicals Dept., Distillation Products Industries, Rochester 3, New York.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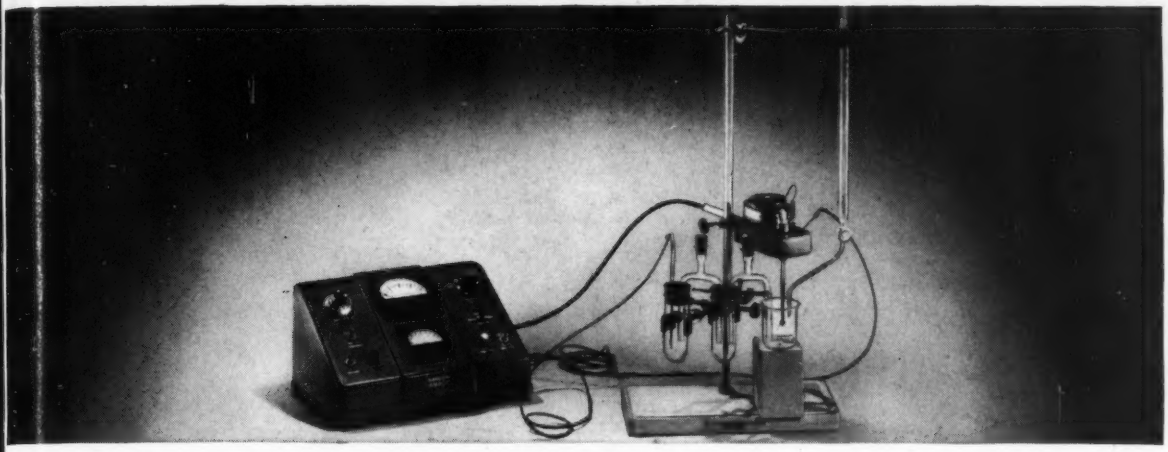

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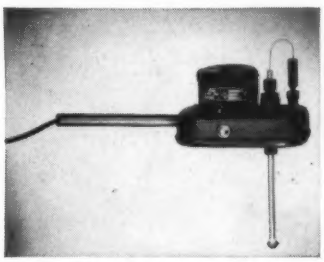

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